ANNEX 7

FOREST FIRE PROTECTION AND FIREFIGHTING PLAN FOR THE POLISH PART OF THE BIAŁOWIEŻA FOREST TRANSBOUNDARY WORLD HERITAGE SITE

IOŚ-PIB
Institute of Environmental Protection
National Research Institute

This material was funded by the National Fund for Environmental Protection and Water Management. Its content is the sole responsibility of the Institute of Environmental Protection – National Research Institute.

Funded by
NATIONAL FUND
FOR ENVIRONMENTAL PROTECTION
AND WATER MANAGEMENT

"Fire protection and forest fire extinguishing plan for the Polish part of the Białowieża Forest Transboundary World Heritage Site"

Warsaw 2019 – 2022 - 2024

Developed by:

Forest Research Institute

Ryszard Szczygieł, PhD, Eng., Head of the Forest Fire Protection Laboratory

Mirosław Kwiatkowski, MSc, Eng., Chief Specialist

Bartłomiej Kołakowski, MSc, Eng., Chief Specialist

State Forest Service

Senior Brig. Piotr Pietraszko, Deputy of the Podlaskie Province Commander of the Provincial State

Brig. Piotr Koszczuk, District Commander of the State Fire Service in Hajnówka,

Brig. Marcin Wierel, Head of the Operations Department of the Provincial Headquarters of the State Fire Service in Białystok,

Junior Brig. Grzegorz Bajko, Deputy District Commander of the State Fire Service in Hajnówka,

Seniot Cpt. Stefan Ostrowski, Senior Specialist at the Operations Department of the Provincial Headquarters of the State Fire Service in Białystok,

Senior Cpt. Piotr Sienkiewicz, Commanding Rescue and Firefighting Unit at the District Headquarters of the State Fire Service in Hajnówka,

Cpt. Marcin Karpiuk, specialist at an independent position for Control and Reconnaissance at the District Headquarters of the State Fire Service in Hajnówka,

Directorate General of the State Forests

Jan Kaczmarowski, MSc, Eng., Forest Service specialist

Regional Directorate of the State Forests in Białystok

Adam Pawłowski, MSc, Eng., Senior Specialist of the Forest Service for Fire Protection

Cooperating units:

Białowieża National Park

Białowieża, Browsk i Hajnówka Forestry Inspectorates

Police (National Police Headquarters, Provincial Police Headquarters in Białystok)

Border Guard (Podlaski Border Guard Regional Unit, Border Guard Unit in Białowieża)

2. Regional Logistics Base - Hajnówka Depot

NGOs associated with Koalicja Kocham Puszczę and foreign experts

(Anja Hoffmann from Germany and Dominik Kulakowski from the US)

Contents:

Preamble 6
1. Assessment of the fire hazard in the Białowieża Forest 8
1.1. Occurrence of fires in the Białowieża Forest 8
1.2. Fire hazard status before bark beetle outbreak occurrence 12
1.3. Current and forecasted fire hazard status, taking into account particularly valuable areas 14
1.4. Factors generating fire hazard for the Białowieża Forest 17
1.4.1. Fire hazard presented by an isolated dead tree 18
1.4.2. Dead wood in the Białowieża Forest 19
1.4.3. Soil cover 27
1.4.4. Subsurface fire hazard 29
1.4.5. Other factors which pose a fire hazard 30
2. Białowieża Forest Fire Protection Plan 31
2.1 Forecasting forest fire hazard for the Białowieża Forest 32
2.2. The Forest Fire Detection System 34
2.3. Alarm and communication system 35
2.4. Extinguishing equipment 36
2.5. Fire access roads 38
2.6. Water supply for fire extinguishing purposes 43
2.7. Fire protection zones (strips) 46
2.8. Preventive actions 46
3. Modeling the spread of forest fires in the Białowieża Forest 47
4. Forest fire extinguishing plan in the Białowieża Forest 51
4.1. Organization of fire protection. National Rescue and Firefighting System 51
4.2. Organization of fire extinguishing operations for large-scale forest fires 53
4.2.1. Reconnaissance 53
4.2.2. Allocation of forces and resources of fire protection units 55
4.3. Forces and resources of the fire protection units of Hajnówka district 56
4.4. Forces and resources of fire protection units of the Podlaskie Voivodeship (province) 59
4.5. Organization of the Provincial Operational Reserve of the National Rescue and Firefighting System in the Podlaskie Province 61
4.6. Organization of the Central Operational Reserve of the National Rescue and Firefighting System in Poland 64
4.7. Performance of fire extinguishing operations 65
4.7.1. Potential Points of Acceptance of Forces and Resources (PPSiŚ) 65
4.7.2. Possibility of using aircraft for rescue operations 67

4.7.3. Organization of the rescue operations staff 69
4.7.4. Cooperation with the State Forests and the Białowieża National Park during rescue operations related to extinguishing forest fires 71
4.7.5. Cooperation with the Police during rescue operations related to extinguishing forest fires 72
4.7.6. Cooperation with the Border Guard during rescue operations related to extinguishing forest fires 74
4.7.7. Principles of organizing cooperation communications in the area of rescue operations related to extinguishing forest fires 75
4.7.8. Logistical support for rescue operations 76
4.7.9 Principles for the exchange of information in the event of a cross-border threat 78
5. Recommendations for fire protection and fire extinguishing in the Białowieża Forest 78
Bibliography 83
List of tables 85
List of figures 86
List of acronyms 87
Symbols of rescue and fire-fighting equipment 87

Preamble

Apart from a buffer zone of 166,708 ha, the Białowieża Forest Transboundary World Heritage Site covers an area of 141,885 ha and is located between 23°31′ and 24°21′ E longitude and between 52°29′ and 52°59′ N latitude. In its Polish part, the area of which is 59,576 ha (42%), its boundaries basically coincide with the line of the compact range of forest ecosystems of the Białowieża Forest (Figure 1). It is a complex of lowland forests, characteristic of the Central European mixed forest ecoregion, whose importance for nature conservation is exceptional. The fire hazard of the Białowieża Forest is influenced by stressors of abiotic, biotic and anthropogenic origin. Their role in the disease process which also affects the aforementioned hazard can be predisposing, initiating or co-participatory. These factors usually interact synergistically and therefore the reaction from the moment the cause occurs is shifted in time, which makes it difficult to interpret the cause-effect relationship.

Abiotic threats derive mainly from the geographical location of the Forest and from the impact of the continental and oceanic climate which result in a thermal structure which differs from one year to another. Weather anomalies lead to increasingly frequent occurrence of extreme air temperatures, precipitation and winds. Analysis of the impact of changes in abiotic factors on the Białowieża Forest (Malzahn et al. 2014, 2018) revealed significant trends in changes in thermal conditions and insignificant or unfavourable tendencies in some precipitation parameters within the last few decades. The most distinct changes in thermal conditions include significant trends of daily temperatures increasing in annual periods and vegetation seasons by about 0.3 °C per 10 years. The result of such a trend is an increase in heat resources, which results in an increase in the number of days with a temperature higher than 5 °C, of hot days in the summer (July), an increasing sum of active temperatures, a decreasing number of days with frost and heavy frost in the spring (March) and a shorter period of permanent snow cover. The ongoing further increase in global temperatures is likely to increase the threat to the Białowieża Forest coming from pathogens and insects and to more frequent forest fires. Changes in hydrological parameters in the Forest point to a tendency towards decreasing water resources of habitats and increasingly difficult conditions for meeting the water needs of tree stands observed within the last 20 years. This phenomenon has been observed in areas of particularly valuable habitats. The amplitude of groundwater level fluctuations is also increasing, and their location is getting lower and lower.
Atmospheric droughts and the resulting hydrological droughts cause a decrease in soil and forest litter moisture, a drop in surface and groundwater levels, a curtailment in tree stand growth and its resistance to stress factors, as well as an increase in fire risk (Miler 2013).

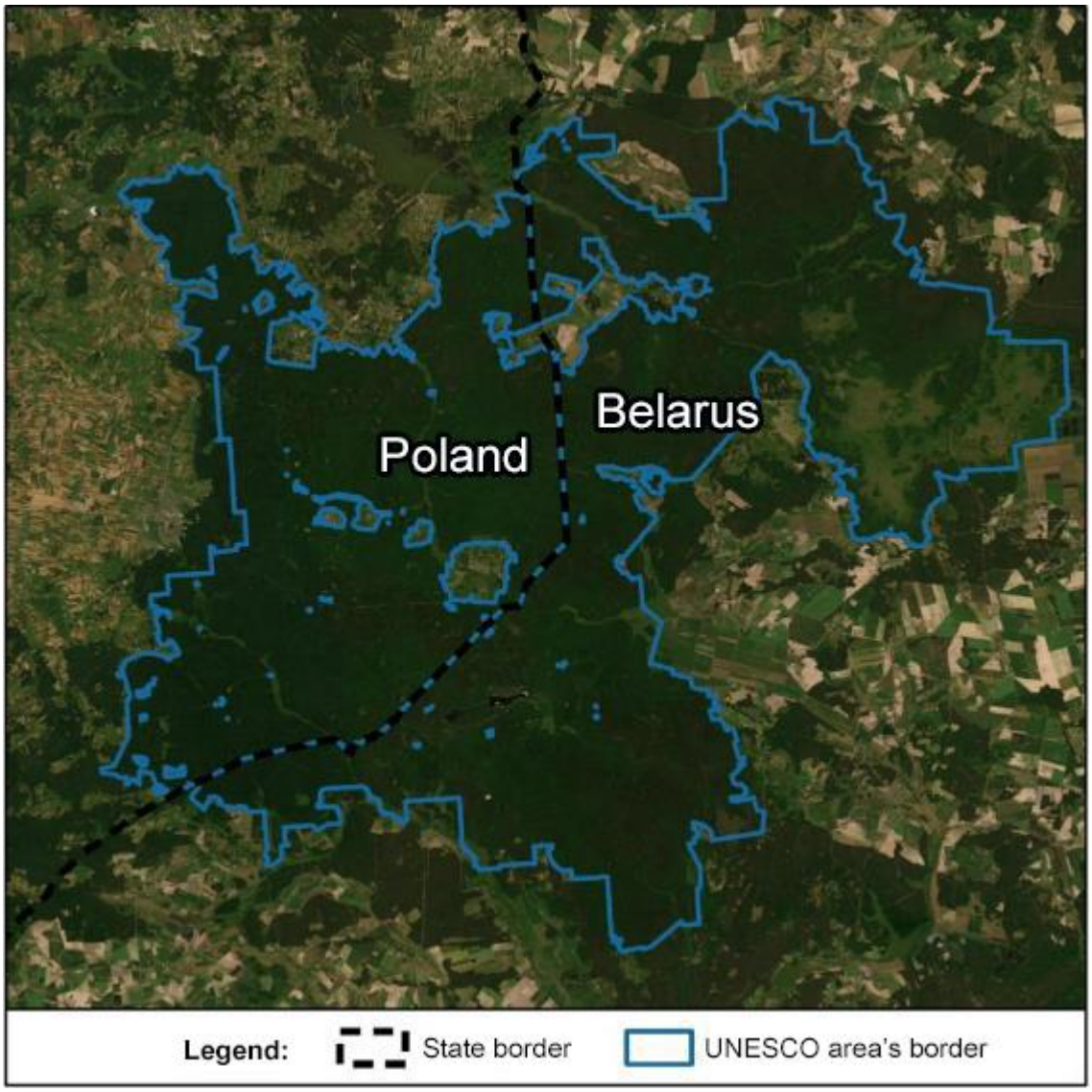


Figure 1. The range of the Białowieża Forest Transboundary World Heritage Site

Due to the threat brought by biotic factors, the area of the Białowieża Forest has been classified as a medium risk zone (Kolk et al. 1996). Since mid-2012, the greatest impact on the potential fire threat has been the massive appearance of the bark beetle (Ips typgraphus), which has resulted in the death of tree stands and their decay. This has led to an unprecedented accumulation of dead combustible material causing a growing risk of fires with increased fire spread dynamics, primarily due to the emergence of grass cover.

The occurrence of a fire depends on the materialization of thermal stimuli capable of initiating combustion, which is related to human activity or presence of people in the forest or its vicinity. According to multi-year data from the National Forest Fire Information System, only about 1% of fires in Poland are provoked by a natural cause, i.e. atmospheric discharge. About 40% of them are the result of arson, i.e. deliberate human action. Urbanized areas in close proximity to the forest and their significant penetration by people are the factors with the greatest impact on the fire hazard in the

Białowieża Forest. According to data from the system, nearly 80% of forest fires occur within a distance of 1 km from human settlements.

The first version of the "Forest Fire Protection and Extinguishing Plan for the Polish Part of the Białowieża Forest Transboundary World Heritage Site" was developed in 2019. The next version, which took into account the results of the "Environmental Impact Assessment" and public consultations of the above-mentioned Plan, was updated in 2022, whereas the current version from 2024 is a correction in accordance with UNESCO's comments and with the discrepancy report submitted by the Institute of Environmental Protection – State Research Institute to the 2022 version of the Plan.

The studies were carried out in accordance with the state of contemporary knowledge and applicable national standards and regulations in the field of fire protection and forest fire protection, including: *the Fire Protection Act of 24 August 1991 (Journal of Laws of 2019, item 1372, as amended), the Regulation of the Minister of Internal Affairs and Administration of 3 July 2017 on the detailed organization of the national rescue and firefighting system (Journal of Laws of 2017, item 1317, as amended). Regulation of the Minister of Internal Affairs and Administration of 7 June 2010 on fire protection of buildings, other construction facilities and areas (Journal of Laws of 2010, No. 109, item 719, as amended) and Regulation of the Minister of the Environment of 22 March 2006 on detailed principles of fire protection in forests (Journal of Laws of 2006, No. 58, item 405, as amended).*

1. Assessment of the fire hazard in the Białowieża Forest

1.1. Occurrence of fires in the Białowieża Forest

In 2000–2024, 138 fires broke out in the Białowieża Forest on an area of 51.20 ha – Table 1. The average area/fire amounted to 0.37 ha and was higher than the average recorded for the State Forests in the aforementioned period, which was 0.30 ha.

A detailed analysis of the types of fires and their causes was conducted in 2019 on the grounds of information obtained from the National Forest Fire Information System, in which data, including i.a. fire coordinates, have been collected since 2007. Soil cover fires dominated (72.7%), which covered as much as 98.2% of the burnt area. In Poland those fires accounted for 88% of the total amount of fires and resulted in 75.2% of the total burnt area. Single tree fires, accounting for 25% of the fires, were very numerous in the Forest, compared to the national average of less than 1%. One subsurface fire was also recorded, but there was not a single total stand fire. Among the fires dominated those caused by arson (27.3%). The next group was composed of fires resulting from negligence (18.2%) and power line failures (11.4%). It should be noted that the percentage of fires provoked by lightning discharges is very high (6.8%), compared to the national average of around 1%, which results from the large number of tall trees growing in the Forest. Rail transport was the cause of 4.5% of fires, while fire spreading from land adjacent to forests provoked 2.3% of them. Fires whose cause was unknown accounted for 29.5% of the total number. A detailed analysis of the causes of fires was performed by comparing the density of fires (pcs/km2) in the Białowieża Forest districts classified in the third category of forest fire hazard

to all forest districts in Poland also classified in this category. In the case of the Białowieża Forest districts, the aforementioned density in 2007-2019 was 8.66 pcs/km2 in the Białowieża Forest, while in the remaining forest districts it was 10.01 pcs/km2, so the values were similar. The distribution of fire density by cause is presented in Figure 2, and their spatial distribution -in Figure 3.

Table 1. Occurrence of fires in the Białowieża Forest in 2000-2024

Year	Number of fires					Area [ha]				
	Forest district			Białowieża National Park	Total	Forest district			Białowieża National Park	Total
	Białowieża	Browsk	Hajnówka			Białowieża	Browsk	Hajnówka		
2000		3	4		7		0.61	1.2		1.81
2001		1	1		2		3.5	1.5		5.0
2002	5	4	5		14	1.6	1.22	5.03		7.85
2003	4	5	6		15	2.31	3.5	0.65		6.46
2004		1	1		2		0.01	0.14		0.15
2005		4	4		8		4.3	0.01		4.31
2006	2	3	6		11	0.01	0.51	1.21		1.73
2007		1	4		5		0.5	0.07		0.57
2008		1			1		0.1			0.1
2009			1	1	2			0.03	6.81	6.84
2010										
2011			2		2			0.01		0.01
2012		1			1		1.5			1.5
2013		1	1		2		0.01	0.02		0.03
2014	2	1	2		5	0.02	0.03	0.02		0.07
2015		2	4		6		2.18	0.05		2.23
2016										
2017										
2018	1	8	1		10	0.01	1.03	0.01		1.05
2019	1	7	3		11	0.01	2.5	0.13		2.64
2020	1	4	6	1	12	0.11	2.9	0.06	1.42	4.49
2021	2	2	1	1	6	0.08	0.46	0.01	0.01	0.56
2022	2	3	1		6	0.02	1.40	0.01		1.43
2023	2	1	3		6	0.31	0.02	0.03		0.36
2024 as at 31.08			4		4			2.01		2.01
Total	**22**	**53**	**60**	**3**	**138**	**4.48**	**26.28**	**12.2**	**8.24**	**51.20**

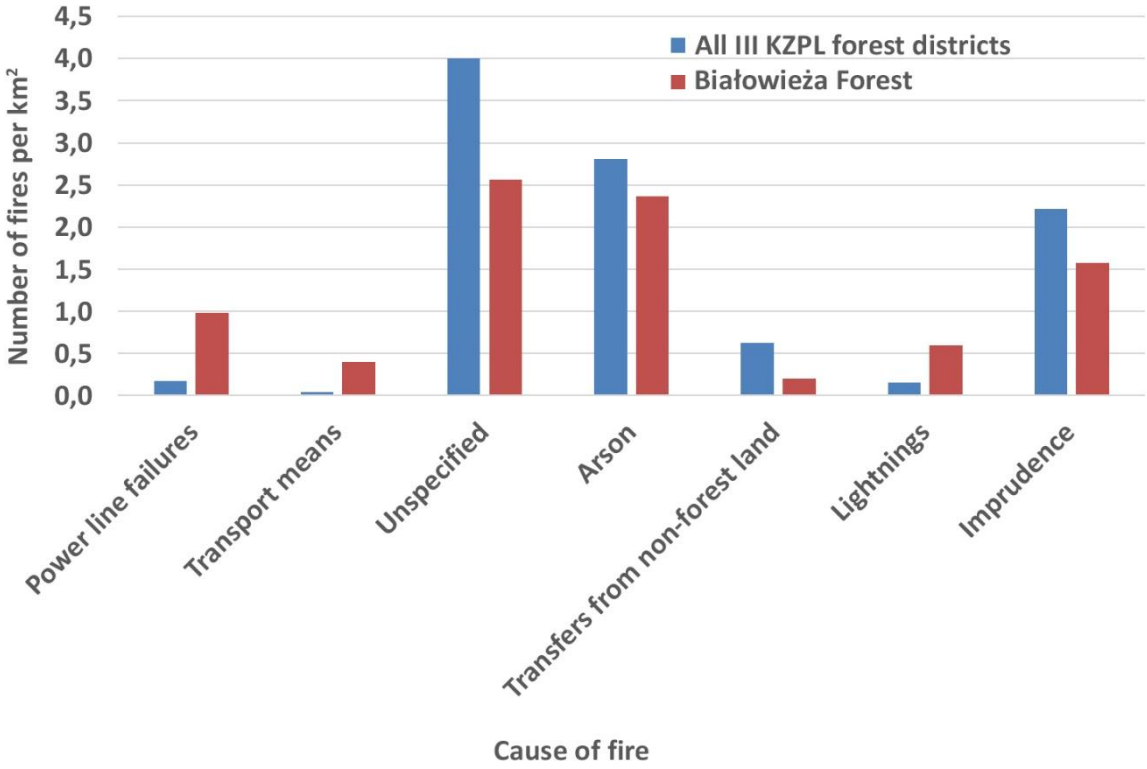


Figure 2. Breakdown of forest fire density in the Białowieża Forest in 2007-2019 by cause

Humans and their intentional or unintentional actions were the main cause of most forest fires. However, comparing the density of fires in the Białowieża Forest districts and in all the forest districts of the III KZPL [Forest Fire Hazard Category], it can be noticed that in the case of the former, the share of fires resulting directly from human activity (arson and carelessness) was clearly lower. The percentage of those caused by fire transfers from non-forest land was also lower, which may result from the compactness of the Białowieża Forest complex. On the other hand, the share of fires associated with infrastructure present in forest areas is significantly higher. In the case of fires caused by power line failures, the density in the Białowieża Forest districts was 6 times higher, while in the case of those related to means of transport (railways) it was as much as 10 times higher. The density of fires provoked by lightning discharges was also higher. In the Białowieża Forest districts it was 0.59 pcs./km2, while in all forest districts of the III KZPL - 0.15 pcs./km2.

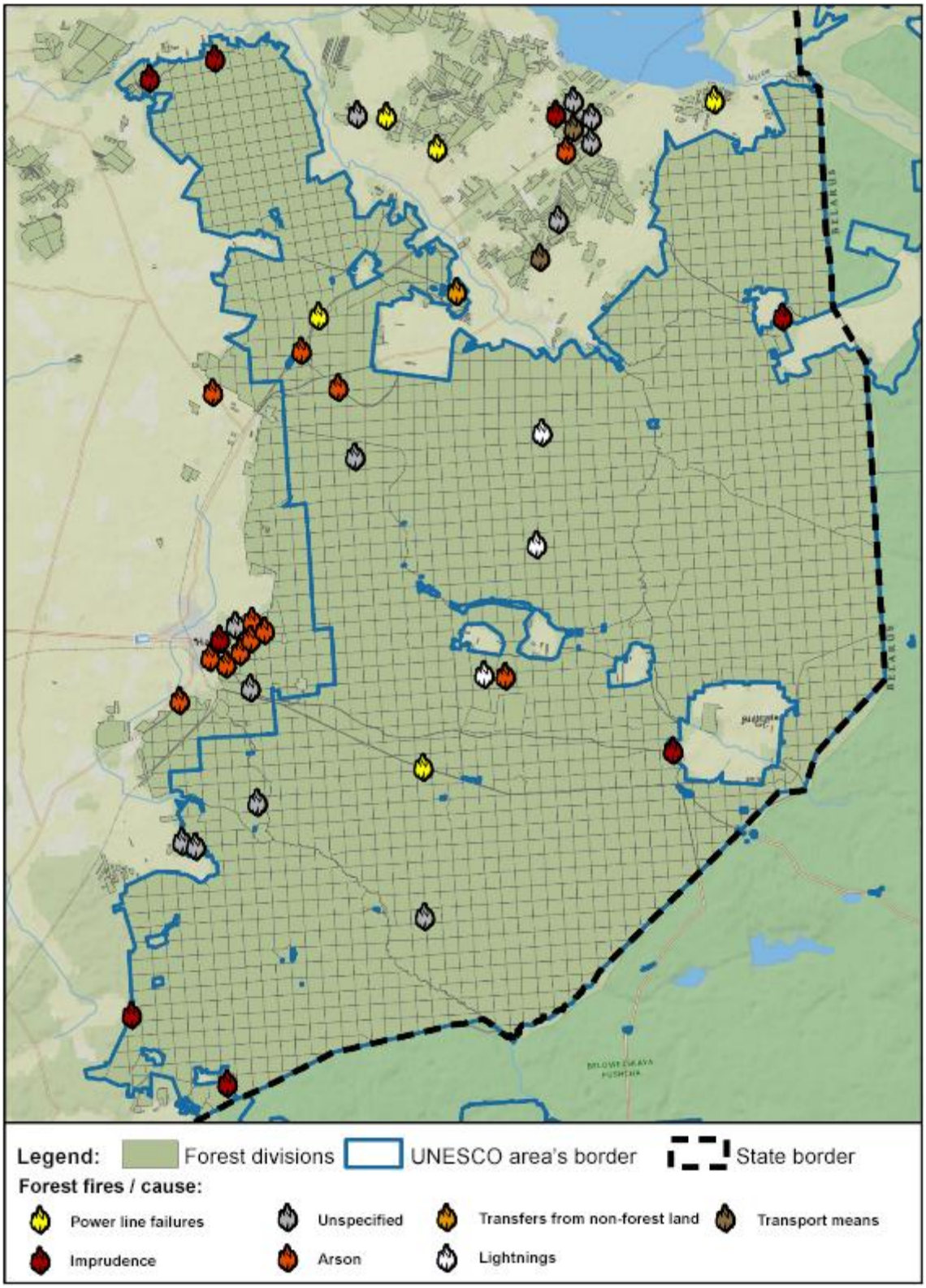


Figure 3. Spatial distribution of forest fires in the Białowieża Forest in 2007-2019 by cause

1.2. Fire hazard status before bark beetle outbreak occurrence

In accordance with the Regulation of the Minister of the Environment of 23 March 2006 on detailed principles of forest fire protection (Journal of Laws No. 58, item 405, as amended), the fire hazard category of the Białowieża Forest was determined on the basis of the total for points resulting from calculations performed for the following parameters:

- the average annual number of forest fires in the last 10 years per 1,000 ha of forest area (P_p) according to the following formula:

$$P_p = 12.5 \log (11.2G_p + 0.725) + 1.5$$

- the sum of percentage shares of the area of tree stands growing in the habitats of dry, fresh, mixed - fresh, moist, mixed - moist coniferous forests and riparian forests (P_d) according to the following formula:

$$P_d = 0.1U_s$$

- average relative air humidity and percentage of days with litter humidity lower than 15% at 9:00 (P_k) according to the following formula:

$$P_k = 0.221U_{ds} – 0.59\ W_p + 45.1$$

- average number of inhabitants per 1 ha of forest area (P_a) according to the following formula:

$$P_a = 2.46 \log (0.0461G_z) + 5.1$$

The following characters were adopted in the above formulas:

G_p – average number of forest fires in the last 10 years per 1000 ha of forest area,

U_s – the sum of the percentage share of the area of tree stands growing in coniferous forest habitats: dry, fresh, mixed - fresh, moist, mixed - moist and riparian forest in the total forest area,

U_{ds} – percentage of days with litter moisture lower than 15% at 9:00 am

W_p – average relative air humidity at 9.00 am,

G_z – average number of inhabitants per 1 ha of forest area.

The number of points calculated according to the aforementioned formulas is added up and if the resulting value is:

≥ 25 points – the forest is classified in the first fire hazard category I (high hazard),

16–24 points – the forest is classified in the second category of fire hazard (medium hazard),

≤ 15 points – the forest is classified in the third fire hazard category (low hazard).

In accordance with the forest management plans for the Białowieża, Browsk and Hajnówka Forest Districts developed by the Office of Forest Management and Geodesy, Białystok Branch in 2011 for the period from 1 January 2012 to 31 December 2021 and the *Protection Plan for the Białowieża National Park* from 2014 (Journal of Laws of 2014, item 1735), the entire area of the Białowieża Forest was then

classified in the third category of forest fire hazard, which did not change when new forest management plans were developed in 2022. Table 2 presents the calculated numbers of points for the forest districts, BPN [Białowieża National Park], as well as for the entire area according to individual criteria. Figure 4 includes a graphical presentation of the fire hazard in the Białowieża Forest and other neighbouring forests.

Table 2. Number of points according to the criteria for determining forest fire hazard according to the classification method as of 2012

Type of parameter	Forest district			Białowieża National Park	Białowieża Forest (total)
	Białowieża	Browsk	Hajnówka		
Tree stand-related factors	2	3	2	2	2
Fire occurrence	4	5	6	1	5
Climate-related factors	3	3	3	3	3
Population density	1	1	1	1	1
Total	**10**	**12**	**12**	**7**	**11**

The forest fire hazard category (pl. kategoria zagrożenia pożarowego lasu - KZPL) comprehensively determines the potential susceptibility of the classified area to fire, taking into account the type of flammable material (the percentage of the most susceptible forest habitat types to fires), weather conditions and their impact on the moisture content of the *Pinus sylvestris L.* pine litter (an indicator significant for Polish forests, determining the possibility of initiating combustion), anthropogenic pressure on the forest (average number of inhabitants per 1 ha of forest area) and the resultant of the above-mentioned factors influencing the actual hazard, expressed by the density of the number of fires over 10 years. The smallest classified unit is the area of a forest district or national park. The forest fire hazard category determines the technical fire infrastructure (forest observation, fire access roads, water draw-off points, firefighting equipment) and the organization of fire protection in the classified area, and consequently the amount of financial investments in its maintenance.

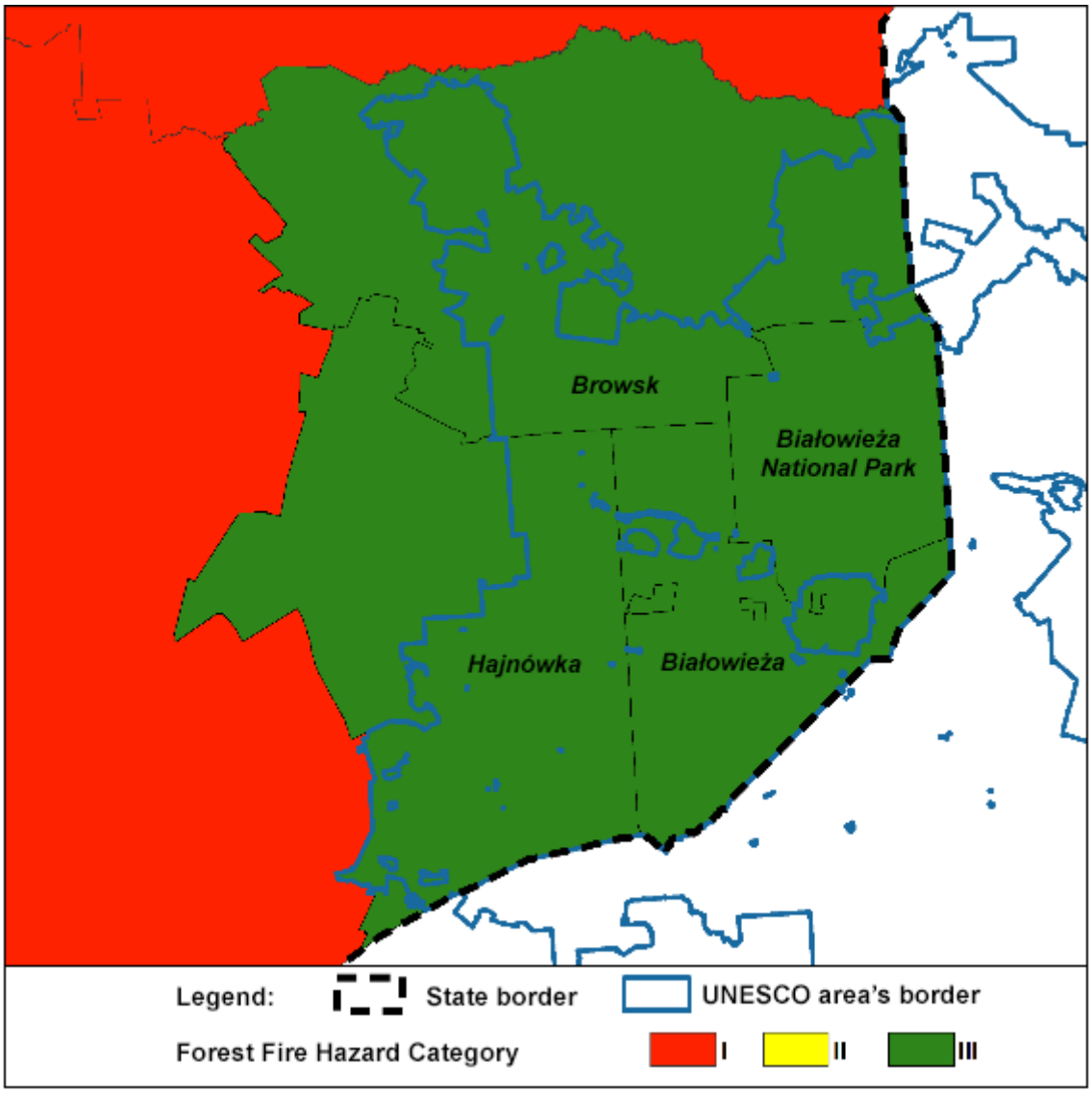


Figure 4. The area of the Białowieża Forest by forest fire hazard category as of 2012

Fire protection in the Białowieża Forest, in accordance with the established third forest fire hazard category, is at the minimum required level. The documents regulating fire protection in the Białowieża Forest districts are *"Forest Management Plans"* and *"Methods of action in the event of a forest fire"*. In the Białowieża National Park, these are the *"Protection Plan"* and *"Methods of action in the event of a forest fire for forest areas of the Reserve protection zone"*.

1.3. Current and forecasted fire hazard status, taking into account particularly valuable areas

The method of categorizing forest areas in terms of fire hazard presented above is a comprehensive assessment on a macroscopic scale (forest district, national park) performed once in every 10 years. Therefore, it cannot be used in the situation of very dynamic and local changes that are occurring in the Białowieża Forest due to the bark beetle outbreak, which basically concern only one of the parameters taken into account in the assessment of fire hazard, which is flammable material. Other climatic and anthropogenic factors and the frequency of fires have not changed significantly.

The current fire hazard status of the Białowieża Forest was determined using the flammability class method developed at the Forest Research Institute (Szczygieł et al. 2017). The flammability class of tree stands reflects their susceptibility to fire and is determined based on the forest site and soil cover types. It is determined using the following formula which allows for calculating the cumulative flammability index WW, taking into account flammability indices for the number of fires and their areas.

$$W_W = 0.8 \bullet W_{SL} + 0.4 \bullet W_{SP} + if(W_{PP} > W_{PL})0,3$$

where:

W_{SL} - flammability index of habitat forest types for the number of fires,

W_{SP} - flammability index of habitat forest types for the burnt area,

W_{PL} - flammability index of forest soil cover types for the number of fires,

W_{PP} - flammability index of forest soil cover types for the burnt area.

The method allows for the classification of tree stands into one of three flammability classes: A – high flammability class, B – medium flammability class and C – low flammability class. Table 3 presents the layout of flammability classes for stands growing in lowland habitats depending on the habitat forest and soil cover types.

Table 3. Flammability classes of tree stands depending on habitat forest and soil cover types

Habitat forest type	Soil cover type						
	Moss MSZ	Moss & bilberry MSZC	Heavily turfed SZAD	Heavily weedy SZCH	Litter ŚCIO	Turfed ZAD	Herbaceous ZIEL
Bog coniferous forest Bb	B	B	B	B	B	B	B
Mixed bog coniferous forest BMb	B	B	B	B	B	B	B
Mix fresh coniferous forest BMśw	B	B	A	A	B	B	B
Mixed moist coniferous forest BMw	A	A	A	A	A	A	A
Dry coniferous forest Bs	A	A	A	A	A	A	A
Fresh coniferous forest Bśw	A	A	A	A	A	A	A
Moist coniferous forest Bw	A	A	A	A	A	A	A
Riparian forest Lł	B	B	B	B	B	B	B
Mixed swamp forest LMb	C	C	C	C	C	C	C
Mixed fresh forest LMśw	B	B	B	B	B	B	B
Mixed moist forest LMw	B	B	B	B	B	B	B
Fresh forest Lśw	C	C	B	B	C	C	C
Moist forest Lw	C	C	B	B	C	C	C
Alder forest Ol	C	C	C	C	C	C	C
Ash alder forest OlJ	C	C	C	C	C	C	C

Flammability classes are established for separated areas and can be generalized to the level of a division or forestry. The method of flammability classes of tree stands supplements the method of

classifying forests into fire hazard categories and meets the requirements of the EU INSPIRE directive, as it allows for mapping fire hazard on a scale smaller than the area of a forest district.

The current classification of tree stands generalized to the division level was developed on the basis of data on habitat forest and soil cover types obtained from the numerical forest maps of specific forest districts, the Białowieża National Park and the results of the field inventory conducted in August 2019. During the inventory, the divisions were inventoried in which the following vegetation posing a particular fire hazard constituted at least 10% of the cover in total:

- Bushgrass (*Calamagrostis epigejos* (L.) Roth) and *Calamagrostis arundinacea* L. Roth. - (BUSHGRASS)
- Plants from the grass family, occurring in fields - (GRASSES)
- Bracken (*Pteridium aquilinum (L.) Kuhn*) - (BRACKEN)
- Common heather (*Calluna vulgaris (L.) Hull*) - (HEATHER)

and separated (delineated) areas where:

- Raspberry (*Rubus idaeus L.*) – grows on fields – (RASPBERRY)
- Common juniper (Juniperus communis L.) – in groups of a dozen or so specimen in close proximity (JUNIPER).

The degree of surface coverage by the aforementioned vegetation was also determined. For the delineated (separated) areas in which any of the above types of soil cover posing a fire hazard occurred, and in which, according to the data from the forest numerical map, there was moss cover, moss-bilberry cover, litter cover, turfed cover or herbaceous cover, a modification was introduced, taking into account the degree of coverage by the above-mentioned vegetation. As a result, these parts of the separated areas were assigned the highest flammability class A in the case of fresh mixed coniferous forest and class B in the case of fresh forest and moist forest. The classes calculated in this way were generalized to the level of the division - map 1.

Taking into account the possibility of an unfavourable development of the fire situation, a map of the forecasted (potentially the most unfavourable) fire hazard of the Białowieża Forest was also developed. It was assumed that there would be a complete disintegration of spruce stands and that forest floor vegetation affecting the increase in fire hazard would develop as a result thereof. Based on the share of spruce in the stands, the degree of coverage with this vegetation was estimated. Then, flammability classes were determined for individual separated areas, just like it was done in the case of the current classification, and they were generalised to the level of divisions – map 2.

Table 4 presents the size of the area of individual flammability classes for the Białowieża Forest and Białowieża National Park districts (current and predicted status - in 2019) and their total percentage share for the entire area of the Białowieża Forest. In 2019, predominant were stands classified as C in terms of flammability (49.1% of the area), stands in class B occupied an area of 39.6%, and the most fire-endangered class A constituted 11.3% of the total area of the Polish part of the Forest. Taking into

account the most unfavourable further changes related to the decay of tree stands and their thinning, it is predicted that in the future (5–10 years' perspective), stands representing the B flammability class (46.3%) are likely to predominate, C class representing ones will constitute 40.3%, and those representative of A class - 13.4% of the total area of the Białowieża Forest. Table 4 presents the fire hazard occurring in 2022 based on valuation data obtained during the development of new forest management plans for the Białowieża Forest districts by the Office of Forest Management and Geodesy in Białystok.

Table 4. The area of Białowieża Forest tree stands according to flammability classes [ha].

Management	Hazard								
	Flammability classes in 2019			Flammability classes in 2022			Flammability classes predicted for 2024 - 2029[1]		
	A	B	C	A	B	C	A	B	C
Białowieża forest district	676	4 891	6 715	1 130	4 306	6 897	824	5 991	5 467
Browsk forest district	2 620	8 607	8 591	2 679	8 275	9 394	3 164	10 164	6 490
Hajnówka forest district	2 653	7 959	8 472	2 199	7747	9 294	3 143	9 205	6 736
Białowieża National Park	920	2 715	6 149	920	2 715	6 149	1 046	2 855	5 882
Total [ha]	**6 869**	**24 172**	**29 927**	**6 928**	**23 043**	**31 734**	**8 177**	**28 215**	**24 575**
Total (%)	**11.3**	**39.6**	**4.1**	**11.2**	**37.3**	**51.4**	**13.4**	**46.3**	**40.3**
Including within the area of the Białowieża Forest World Heritage Site									
Total [ha]	**4 809**	**18 154**	**28 218**	**5 607**	**19 427**	**30 505**	**4 809**	**16 591**	**22 922**
Total (%)	**9.4**	**35.5**	**55.1**	**10.1**	**35.0**	**54.9**	**10.9**	**37.4**	**51.7**

1.4. Factors generating fire hazard for the Białowieża Forest

The analysis of factors posing a fire hazard in the Białowieża Forest focuses primarily on flammable material (crucial in assessing fire risk), i.e. alienated dead wood and changes in soil cover, which are a consequence of the bark beetle outbreak. Other factors that affect the potential fire hazard were also indicated and should be considered as places of increased risk of the occurrence and spread of a forest fire.

[1] The forecast was made in 2019. The difference in areas between the forecast and 2022 results from the fact that the forecast was made using data for which there was a complete data set. As a result of the update of the Forest Management Plans in 2022, the areas taken into analysis were larger.

1.4.1. Fire hazard presented by an isolated dead tree

As a result of gradual, natural biological processes spread over time, dead wood appearing in a forest does not result in a significant increase in fire risk due to excessive amounts of fuel. From the point of view of nature, dead wood, regardless of its quantity, does not represent any threat, although standing dead trees may pose a safety risk to people staying in the forest, especially along roads and tourist trails. Abiotic or biotic disturbances, as a result of which there is a rapid increase in the amount of dead wood, increase the potential risk of forest fires. According to data from the Large-Area Inventory of the Condition of Forests from 2014–2018 (WISL 2019), the average volume of standing and lying dead trees in forests of all forms of ownership in Poland amounted to 8.0 m3/ha in total. Considering that coniferous species constitute 55.7% of dead wood, it was estimated that this corresponds to an average fire load (defined as the amount of biomass per unit area expressed in kg/m2 or t/ha) of about 5 t/ha. In national parks, the average mass of dead wood was 45 m3/ha.

The fire hazard brought by dead wood depends primarily on its size, degree of decomposition and type (Szczygieł et al. 2016). Generally, it can be stated that the larger the size of dead wood, the lower the hazard. The greatest fire hazard is posed by small wood (diameter of up to 7 cm), because medium-sized one (diameter from 7 to 40 cm) and large-sized one (diameter over 40 cm), due to the slow change in water content and its relative stability usually at a level exceeding the threshold of ignition possibility (this threshold is assumed to be the humidity of the combustible material at the level of 30%), do not pose a significant and real fire hazard.

Taking into account the classes of dead wood decay (Maser et al. 1979), in terms of fire hazard, it should be stated that lying dead wood poses the greatest risk of fire occurrence and rapid spread in the first class of decay. This is caused primarily by the occurrence of small branches with a diameter of up to 3 cm, in the initial phase even with dried needles or leaves, intact bark and a loose spatial structure being the result of branched logs leaning against the ground. Fire hazard decreases when the log is already devoid of small branches, the texture is intact or only slightly damaged, and the log has not fully settled on the ground. In the 3rd and 4th class of decay, due to the decrease in wood density and more favorable access of air, especially when the log is lying in open and sunny places when periods without precipitation are longer, the rotting wood can burn, usually without flames, and the combustion process is characterized by a long and slow course. In the highest 5th class of decay, the fire hazard practically does not occur.

In the case of standing dead wood, the greatest fire hazard is posed by living and dying trees (class 1 and 2), which results from the linear continuity of combustible material, provided by small, drying branches, which allow the soil cover fire to easily transform into a top fire. In the subsequent classes (3–8), this hazard decreases significantly. In the final stage (class 9), stumps may correspond to a place of long-term maintenance of mainly flameless combustion due to annealing. In general, it should be stated that lying dead wood poses a greater fire hazard than the standing one, which results from the lack of

linear continuity of combustible material, which occurs as early as in class 3 of standing tree decomposition.

1.4.2. Dead wood in the Białowieża Forest

The amount of flammable material and its type are the basic criteria for assessing potential fire risk, although they are not reflected in the applicable classification methods. They determine the energy balance of the fire, its spread, and, consequently, the losses in the tree stand affected by the fire. Dead flammable materials are of a special importance, not only in the initial phase of combustion, but also in shaping the conditions for the spread of fire. Before the bark beetle outbreak in the Białowieża Forest, an inventory of dead wood was carried out in 2010-2011 as part of the revision of the Forest Management Plans of the Promotional Forest Complex of the Białowieża Forest. The average amount of dead wood in the three districts of the forest was 24.9 m3/ha. Considering the average density of wood with a moisture content of 15% (spruce, pine, oak and hornbeam - the main forest-forming species in the Forest), the fire load amounts to approximately 15.8 t/ha. By comparison, the average volume of dead wood in the State Forests at that time was 5.3 m3/ha, in private forests – 4.2 m3/ha, and in national parks – 37.3 m3/ha (WISL 2012). According to BPN's data, the amount of dead wood in 2009 in the Orłówka Protection District was 108 m3/ha (standing wood) and 50 m3/ha (fallen wood), and in the Hwoźna District - 38 and 43 m3/ha respectively. As a result of the disintegration of spruce stands provoked by the bark beetle outbreak, there was a drastic increase in the amount of dead wood and, as a result, an increase in the potential fire threat to the Białowieża Forest.

In 2012 (since June) in the Białowieża Forest districts in the areas covered by the outbreak, the average volume of dead wood doubled (50.2 m3/ha) compared to 2011, and in 2017 it increased more than ninefold, reaching a maximum value of 231.8 m3/ha. In 2018, the aforementioned value dropped slightly, and a significant decrease occurred in 2019 when it went down to 126.5 m3/ha. Table 5 presents aggregate data (source: Regional Directorate of the State Forests in Białystok) on the volume of inhabited spruces and the size of the areas where the decay of tree stands occurred, as well as the volume of dead wood per unit area before and after partial removal of inhabited trees.

The spatial distribution of standing dead wood in 2018 obtained from airborne ALS (Airborne Laser Scanning) scanning performed as part of the Life+ ForBioSensing project is shown on map 3.

Table 5. Thickness of spruce trees infested by the bark beetle and the area of dead stands in 2012–2019

Year	Thickness of inhabited spruces	Thickness of removed spruces	Area of dead tree stands	Quantity of dead wood	
				Before removal	After removal
	m^3	m^3	ha	m^3/ha	
2012 (since June)	23 289	6 412	464	50,2	36,4
2013	102 592	19 610	689	148,9	120,4

Year	Thickness of inhabited spruces	Thickness of removed spruces	Area of dead tree stands	Quantity of dead wood	
				Before removal	After removal
	m^3	m^3	ha	m^3/ha	
2014	198 123	25 488	1 482	133,7	116,5
2015	267 080	42 288	2 088	127,9	107,6
2016	483 683	39 148	2 498	193,6	177,9
2017	366 982	162 020	1 583	231,8	129,5
2018	323 861	3 085	1 470	220,3	218,2
2019	128 522	253	933	137,7	137,5

In 2019, the total volume of spruce trees infested by the bark beetle amounted to 1,894,522 m3 on an area of 11,207 ha. Wood removal and disposal (totalling 288,672 m3) allowed for a small (approximately 15%) reduction in the mass of dead wood remaining in the forest in the analyzed period. In 2020–2022, the rate of dead wood removal significantly decreased, as in that period the mass of infested spruce trees amounted to 39,764 m3 (in the years: 23,571, 10,902 and 5,291 m3 respectively) on a total area of 254 ha (in the years: 218, 35 and 1 ha respectively).

Based on the presented source data, the changes in the average fire load were calculated, both for individual years (Table 6) and cumulatively, taking into account the total mass of inhabited spruces and the area of dead stands (Table 7). In the calculations, it was assumed that the density of spruce wood with 15% moisture content was 470 kg/m3.

Table 6. Calculation results of the average fire load in 2012-2019

Year	Mass of inhabited spruces	Surface of dead tree stands	Average fire load of inhabited spruces /	
			Before removal /	After removal
	t	ha	t/ha	t/ha
2012 (since June)	10 945.8	464	23.6	17.1
2013	48 218.2	689	70.0	56.6
2014	93 117.8	1 482	62.8	54.7
2015	125 527.6	2 088	60.1	50.6
2016	227 331.0	2 498	91.0	83.6
2017	172 481.5	1 583	108.91	60.9
2018	152 214.7	1 470	103.5	102.6
2019	60 405.3	933	64.7	64.6

Table 7. Calculation results of the increasing average fire load in 2012-2019

Year	Mass of inhabited spruces	Total surface of dead tree stands	Average fire load of inhabited spruces	
			Before removal	After removal
	t	ha	t/ha	t/ha
2012 (since June)	10 945.8	464	23.6	17.1
2013	59 164.1	1 153	51.3	40.7
2014	152 281.9	2 635	57.8	48.6

Year	Mass of inhabited spruces	Total surface of dead tree stands	Average fire load of inhabited spruces	
			Before removal	After removal
	t	ha	t/ha	t/ha
2015	277 809.5	4 723	58.8	49.5
2016	505 140.5	7 221	70.0	61.3
2017	677 622.0	8 804	77.0	61.2
2018	829 836.7	10 274	78.2	78.0
2019 (until 30.09)	890 241.7	11 207	79.4	79.4

The fire load was the lowest at the beginning of the bark beetle outbreak in 2012 when it amounted to 23.6 t/ha. In the following years, it increased to 60-90 t/ha, reaching an average maximum value of 108.9 t/ha in 2017. According to detailed inventory data, the maximum amount of dead wood in some separated areas was as much as 629 m3/ha, which corresponds to a fire load of 295.6 t/ha. The limit above which it becomes impossible to extinguish a fire is when the fire load exceeds 10 t/ha (Castellnou and Hernandez 2018). The cited Spanish experts estimate that in most European forests these loads reach 30 t/ha, which, in the event of a fire occurring during a period of prolonged droughts and extremely high temperatures, leads to catastrophic, intense forest fires, such as those that occurred in Portugal in 2017 and in Greece and Sweden in 2018, when rescue services were basically helpless when confronted with the raging element.

Since dead wood poses the greatest fire hazard, pilot field measurements of fire load were carried out by random selection of five locations with particularly high concentrations of deadwood aimed at determination of maximum loads. The boundaries of each selected area (16 m2 on average) were marked and then the deadwood was weighed. The measured fire loads ranged from 86.76 to 139.88 t/ha, with an average of 105.77 t/ha in dry conditions. Such an amount of dead wood increases the risk of a fire with increased spreading dynamics. This hazard increases especially in those locations where dead trees with withered branches, with a loose spatial structure that favors the initiation and intensification of combustion, lie on the ground, additionally facilitating the possibility of fire spreading into the crowns of still living trees and standing dead trees with withered crowns. Standing dead spruce trees will fall over or break over time (according to experts, this process can take 3-6, and no more than 10 years on average), which will lead to an increase in the fire load of lying dead wood, which, from a risk assessment perspective, results in a greater fire hazard than standing wood. Due to their density, logs lying on the forest floor currently generate a lower fire hazard due to their lower susceptibility to ignition compared to other types of forest materials. However, over time, as the wood decomposes, their fire role will change, and in the event of a fire, they will constitute a material susceptible to ignition, which will prolong the duration of combustion. Lying dead trees can also significantly hinder any rescue and firefighting operations by preventing access for rescue units, and also block access to places covered with fire. Such a situation occurred during a fire that broke out on May 18, 2024 in the Topiło Forest District in the Starzyna Nature Reserve (division 699 B and D). A large amount of accumulated dead

wood in the form of lying logs and standing and hanging trees made it hard for the intervening fire brigades to access the burnt area of 1.98 ha, which was almost five times larger than the average fire area in 2000-2024. The fire extinguishing operation took almost 24 hours, while extinguishing operations and supervision over the fire site - as long as 17 days.

In the first 3 years after their death, the trees are mostly standing and maintain most of their branches, including the smallest ones in the initial phase with dried needles. In the rare cases when a tree falls, it has a loose spatial structure because its branched log with numerous dried small branches, on which grass vegetation emerges quickly leans on the ground. In the following years, the thinner branches fall and after the subsequent 4-5 years, only fragments of the thickest branches remain on the trees. At this time, some of the standing dead trees begin to fall over, often resting on fragments of branches, which contributes to the acceleration of branch decomposition. After about 8 years, most of the dead trees are already fallen or broken, and those that have fallen lie directly on the ground, covered with a layer of moss, which accelerates their further decay. After about 10 years, the process of decomposition of lying dead wood is already highly advanced, and the degree of its decay depends on the environmental conditions, which are influenced by the type of habitat, temperature, humidity, sunlight, etc.
Observations show that the fire risk reaches its maximum level in the 2nd–3rd year of tree stand decay, not only due to the amount of dead combustible material, but above all due to its high potential susceptibility to ignition and spread of fire. Fire can easily develop due to the vertical (standing dead trees) and horizontal (grass cover and lying dead trees) linear continuity of flammable fine combustible material (Fig. 5, 6). A greater fire risk is posed by lying dead wood, especially in combination with a readily flammable soil cover. In the following years (4–7), the fire risk begins to go down, and its level can be considered medium (Fig. 7). A low fire hazard is observed within 8–10 years. However, after 10 years from the dieback of the tree stand, the fire hazard caused by the dead wood which has been left behind reaches a minimum level, and the possibility of initiating the combustion of such material is almost completely reduced (Fig. 8). The model course of the potential fire hazard for the subsequent years of stand decay in the Białowieża Forest is presented in Fig. 9. Considering that in 2019 the volume of spruce trees inhabited by bark beetles decreased significantly, it can be assumed that the fire hazard will return to the levels observed before the bark beetle outbreak around 2029.

Figure 5. Dead trees in the initial phase of stand decay pose a significant fire hazard due to the presence of large amounts of fire-active biomass.

Figure 6. Dead trees lying with small, dry twigs covered with grass pose a major threat.

Figure 7. Medium fire hazard occurs when there is a loss of fine flammable material, causing a lack of linear continuity that allows fires to spread easily.

Figure 8. Dead wood in an advanced stage of decomposition generates a minimal fire hazard, due to its structure which practically excludes the possibility of initiating combustion and limits the spread of fire.

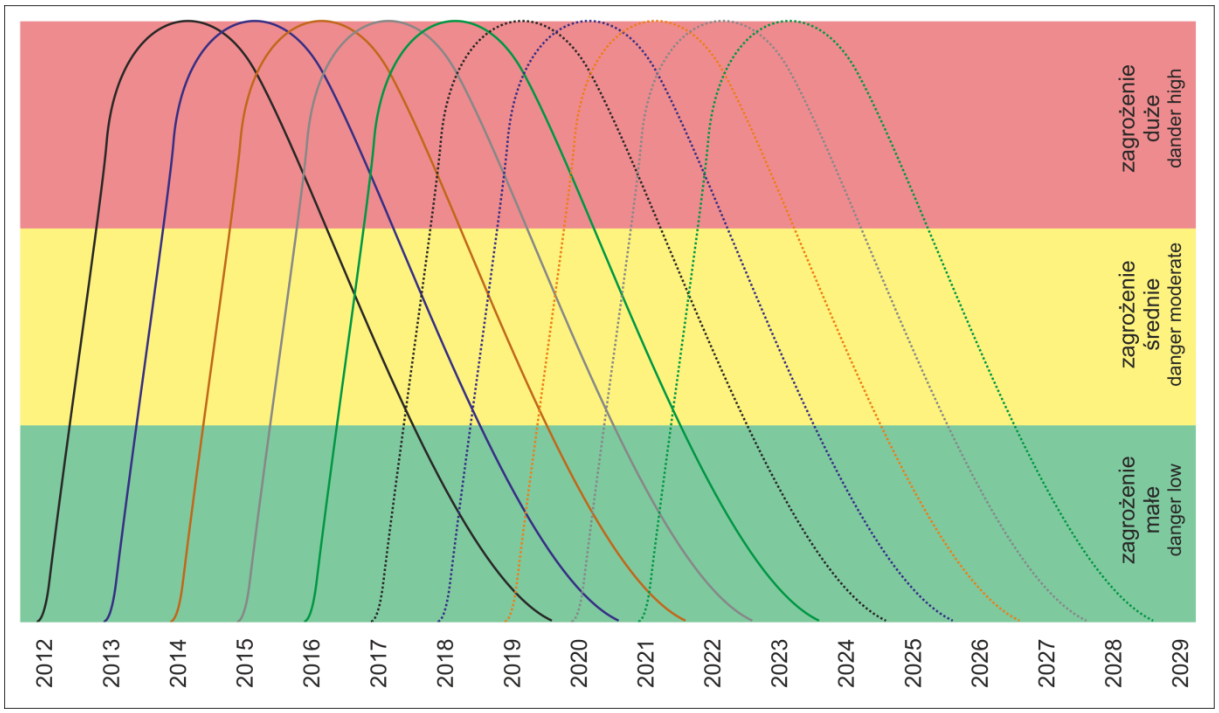


Figure 9. Model course of potential fire hazard for dead stands of the Białowieża Forest in 2012 – 2029

A detailed nature inventory in the Białowieża Forest carried out in 2016-2018 by the State Forests as a part of a large-scale nature inventory allowed for a detailed assessment of the degree of decomposition of dead wood. The inventory methodology distinguishes 3 classes of decomposition:

1. undecomposed wood – with an unchanged structure, not covered with mycelium or lichens, in the case of felled trees with a light front or a resinous surface in the place of cutting,
2. partially decomposed wood – characterized by the presence of mycelium or lichens, dark discoloration of the front, visible traces of rot along the circumference or in the heartwood,
3. heavily decomposed wood – heavily covered with mycelium, lichens and mosses, sometimes with a completely decomposed sapwood part and partially preserved heartwood.

The greatest fire hazard is caused by dead wood in the 1st class of decay (similar to the Maser classification), a small hazard - by wood representing the 2nd class of decay, and the minimum level of hazard refers to the 3rd class of decay. A detailed analysis taking into account the degrees of decay and tree species (tables 8-10) demonstrates the dominance of spruce, whose share in total dead wood was 49.38% in 2016, 58.78% in 2017 and 63.02% in 2018, respectively, which is much more than the overall share of spruce in the Białowieża Forest which is below 30%. What is very important is that the share of spruce in the 1st class of decay, when trees still have a significant number of small branches, has clearly increased in the last two years. In 2016 it was 24.45%, and in 2017 and 2018, respectively, 39.65% and 38.83%. In total, dead wood in the 1st class of decomposition, potentially posing the greatest fire risk, accounted for a bit more than 40% in 2016, almost 52% in 2017 and nearly 48% in 2018. In the longer term, if the decay of stands is halted, the fire hazard currently posed by dead wood will gradually decrease due to its progressive decomposition. The spatial distribution of dead wood broken down to the degrees of its decomposition is shown on Map 4.

Table 8. The share of dead wood in the Białowieża Forest depending on the species and the degree of decomposition in 2016

Species	Share of dead wood [%]				
	Broken trees	Degree of decomposition			In total
		1	2	3	
Pine	0.11	1.13	2.68	0.74	4.66
Birch	0.04	0.74	1.52	1.96	4.26
Oak	0.09	3.70	2.30	3.17	12.10
Hornbeam	0.08	0.24	0.65	1.59	2.56
Ash	0.00	4.55	4.70	2.89	12.14
Alder	0.03	3.32	3.50	4.39	11.23
Spruce	0.29	24.45	12.51	12.12	49.38
Other	0.05	0.88	1.17	1.57	3.67
In total	**0.69**	**40.02**	**30.27**	**29.02**	**100.00**

Table 9. Share of dead wood in the Białowieża Forest depending on species and degree of decomposition in 2017

Species	Share of dead wood [%]				
	Broken trees	Degree of decomposition			In total
		1	2	3	
Pine	0.04	1.28	2.40	0.71	4.42
Birch	0.05	0.73	1.24	1.79	3.81
Oak	0.07	2.45	1.60	1.35	9.36
Hornbeam	0.11	0.30	0.47	1.38	2.26
Ash	0.00	2.95	4.53	2.04	9.52
Alder	0.02	2.66	2.57	3.43	8.68
Spruce	0.61	39.65	10.65	7.86	58.78
Other	0.04	0.71	1.14	1.26	3.15
In total	**1.04**	**51.40**	**26.53**	**21.03**	**100.00**

Table 10. Share of dead wood in the Białowieża Forest depending on species and degree of decomposition in 2018

Species	Share of dead wood [%]				
	Broken trees	Degree of decomposition			In total
		1	2	3	
Pine	0.49	1.64	1.89	0.60	4.62
Birch	0.79	0.79	0.90	1.37	3.85
Oak	0.53	2.59	2.09	2.55	7.76
Hornbeam	0.34	0.21	0.29	1.26	2.10
Ash	0.10	2.06	3.28	2.01	7.45
Alder	1.14	1.40	2.67	3.18	8.39
Spruce	3.07	38.82	13.22	7.91	63.02
Other	0.59	0.46	0.69	1.07	2.81
In total	**7.05**	**47.97**	**25.03**	**19.95**	**100.00**

1.4.3. Soil cover

In the areas where spruce stands disintegrated, grass cover appeared en masse, mainly made up of reed grass. The vegetation that makes up these grass clusters when the conditions are dry (early spring, periods of summer droughts, early autumn) generates a high fire hazard, facilitating the possibility of fire and its rapid spread. In 2016, a field inventory of such areas was carried out in the forest districts. It included an inventory of the separated areas where the following vegetation, posing a particular fire risk, constituted at least 10% of the cover in total:

- Bushgrass (Calamagrostis epigejos (L.) Roth) and Calamagrostis arundinacea L. Roth. - (BUSHGRASS)
- Plants from the grass family, occurring in fields - (GRASSES)
- Bracken (Pteridium aquilinum (L.) Kuhn) - (BRACKEN)
- Common heather (Calluna vulgaris (L.) Hull) - (HEATHER)

and separated areas where:

- Raspberry (Rubus idaeus L.) – grows on fields – (RASPBERRY)
- Common juniper (Juniperus communis L.) – in groups of a dozen or so specimen in close proximity (JUNIPER).

The degree of surface coverage by this vegetation was also determined. Areas where the bark beetle outbreak occurred were taken into account in the first place. The summary results of the inventory are presented in Table 11, which includes a summary of the surface according to dominant type of plants, soil cover and degree of coverage.

Table 11. Results of field inventory of tree stands with soil cover generating a high fire hazard – 2016

Surface of tree stands [ha]					
Plants dominant in the soil cover	Degree of coverage [%]				
	10	20	30	40-100	In total ha]
Heather and juniper	159.73	219.28	218.96	20.48	618.45
Ferns	288.90	440.34	269.99	216.39	1 215.62
Grass	1 539.50	1 446.66	1 290.54	1 416.99	5 693.69
In total	**1 988.13**	**2 106.28**	**1 779.49**	**1 653.86**	**7 527.76**

Their total area was 7527.76 ha, which constituted almost 15% of the forest area of the forest districts of the Białowieża Forest. The largest area was occupied by grass cover with an admixture of raspberry (5693.69 ha), then by cover with common bracken or an admixture of raspberry, and the smallest cover was heather with juniper, concentrated primarily in the northern part of the Browsk Forest District, which is outside of the reach of the World Heritage Site.

In order to determine the amount of combustible biomass, field measurements of the fire load of these covers were performed in places where the stands were thinned and on the reference surface in case of the grass cover. The measurements consisted of weighing the vegetation on surfaces of 1 m2 and determining the moisture content of the material in order to calculate the load of the materials in dry conditions. They were performed on a total of 35 randomly selected surfaces, including 15 representative for grasses, 10 for ferns, 5 for the raspberry cover and 5 reference ones. The average results of the fire load measurements for the covers responsible for the greatest fire hazard in the Białowieża Forest are presented in Table 12.

Table 12. Averaged fire load for selected soil cover types

Type of cover	Average layer height [cm]	Average fire load [t/ha]
grass	129	25.0
ferns	116	36.7
with raspberry	89	28.7
grass/reference	15	9.7

These loads were 25.0 t/ha for the grass cover, slightly more, 28.7 t/ha, for the raspberry cover and 36.7 t/ha for the fern cover. The measured fire load for the grass cover ranged from 11.7 to 45.6

t/ha, the one for the raspberry cover from 23.6 to 32.7 t/ha, and the one for the fern cover from 19.2 to 79.9 t/ha, which reveals a high variability in the amount of combustible biomass for all types of covers tested. On the reference areas for the grass cover, the average fire load was about 2.5 times lower (9.7 t/ha) compared to the areas subject to thinning and ranged from 4.4 to 13.6 t/ha. The fire load for grasses in other lowland stands in Poland where studies had previously been conducted was on average 5.0 t/ha, i.e. as much as 5 times less than in stands severely overexposed due to the bark beetle outbreak.

In 2019, a field inventory of areas with cover generating a high fire hazard was carried out again in the Białowieża Forest districts using the same methodology; the total results thereof are presented in Table 13.

Table 13. Field inventory results for the area of stands with soil cover generating a high fire hazard – 2019

Surface of tree stands [ha]					
Plants dominant in the soil cover	Degree of coverage [%]				
	10	20	30	40-100	In total [ha]
Heather and juniper	148.73	211.88	211.00	12.00	583.61
Ferns	1 163.56	976.55	785.87	1 177.44	4 103.42
Grass	2 059.16	1 977.22	1614.64	3 565.83	9 216.85
In total	**3 371.45**	**3 165.65**	**2 611.51**	**4 755.27**	**13 903.88**

Compared to 2016, the total increase in the area of soil cover with high fire risk was almost twofold, as it covered an area of almost 13,904 ha, which corresponded to as much as 26% of the area of forest districts. The area with fern cover increased the most (almost 3.5 times), while the area with grass cover (an increase of almost 1.5 times) occupied the largest area of 9,217 ha. Map 5 shows the spatial distribution of the area with vegetation of soil cover increasing the fire risk. Grass cover poses the greatest fire risk when dried out, due to its loose spatial structure, the height of the fuel bed and the fact that it occurs on exposed surfaces, where wind speeds are significantly higher than in the tree stand, which also affects its rapid drying. The model calculations of the speed of spread of a grass cover fire on the exposed surfaces resulting from the collapse of stands have shown that it will be 4 to 7 times greater, and the fire area will increase almost 50 times in comparison to the soil cover fire before the collapse of stands. The expected sizes that fires can achieve in the changed environmental conditions should be taken into account at the stage of allocation of forces and resources in the event of actual fires.

1.4.4. Subsurface fire hazard

Peat subsurface fires are among the most persistent and require large expenditures of forces and resources as well as time-consuming fire monitoring. They are also extremely destructive to the natural environment. When the water content is high, peat bogs do not generate any hazard in terms of fire. However, when they dry out as a result of changes in the environment, long-term droughts or drainage operations, we face the accumulation of a large amount of fire load. In areas with deposited layers of

organic soil, determined as a result of the performed field inventory, peat thickness measurements were taken on randomly selected surfaces of different forest habitat types.

The estimated classification of organic soil areas in the Białowieża Forest in terms of their thickness is presented in Table 14, and the spatial distribution is visible on the map 6.

Table 14 Estimated classification of organic soil areas in the Białowieża Forest in terms of their thickness

Description	Area [ha]
Mostly coniferous habitats with peat thickness ranging from a dozen to several dozen centimetres	758.36
Forest habitats with peat thickness ranging from several dozen centimeters to more than 1 meter	9 091.51
Non-forest areas - mainly in riverbeds with unspecified peat thickness	214.99

1.4.5. Other factors which pose a fire hazard

Anthropogenic environmental impact is the main factor influencing the potential threat to the Białowieża Forest. According to the only available data from the Białowieża National Park, the number of people visiting the Park in 2015–2023, based on tickets sold and registered entries, is estimated at an average of 260 to 318 thousand per year – Table 15. These are probably overstated figures, as people can visit different places during their stay in the Białowieża Forest. Taking into account also the uncontrolled penetration of forest areas by the local population, it is estimated that the Forest may be visited by 150 to 200 thousand people a year. The anthropogenic impact translates into a large number of fires, especially in the Hajnówka and Browsk Forest Districts, in areas located close to human settlements and in the buffer zone of the Forest, where the most forest fires have occurred. In accordance with § 12 of *the Regulation of the Minister of Environment of 23 March 2006 on detailed principles of forest fire protection,* a ban on entering a forest is introduced in the case of high fire risk (3rd level of forest fire risk – see chapter 2.1.), if for five consecutive days the humidity of the litter measured at 9:00 am is lower than 10%. It is also possible to consider establishing principles for managing the movement of people in the Białowieża Forest, aimed at limiting access, especially to areas with high potential risk during periods of increased forest fire risk. Monitoring anthropogenic pressure, especially in the most attractive tourist locations and areas most at risk in terms of fire, would allow for obtaining more accurate data on the number of people staying in the forest and, on the other hand, would be a preventive measure.

A very important factor that should be taken into account when assessing the risk of fire in the Forest is the current situation on the border with Belarus. The "Forest Fire Protection and Fire Extinguishment Plan for the Polish Part of the Białowieża Forest Transboundary World Heritage Site" developed in 2019 and its supplemented version in 2022 did not take into account this risk resulting from illegal immigration. This situation should also be monitored in terms of possible and actual threats to the Forest's fire safety. This is confirmed by examples of fires started by immigrants who made

bonfires in order to get warm. It should also be noted that fires are lit not only by foreigners, but also by people guarding the border.

Table 15. Number of people visiting Białowieża National Park in 2015-2023

Location	Year								
	2015	2016	2017	2018	2019	2020	2021	2022	2023
Nature and Forest Museum	71 998	81 799	72 992	68 822	72 850	30 454	31 283	28 101	53 831
European Bison Show Reserve	132 865	163 365	149 683	156 178	173 563	158 176	142 470	97 847	144 789
Sierganowo Protection District	21 568	28 774	25 996	26 645	27 921	20 753	17 281	8 463	15 792
Reserve Protection District	*21 000*	*24 000*	*26 000*	*24 000*	31 816	46 000	no data	no data	no data
Kosy Most	*12 000*	*20 000*	*14 000*	*12 000*	18 181	26 000	no data	no data	no data

Note: *Numbers in italics* – estimative data

Potential fire hazards also result from road and rail communication routes and power lines running through the Forest or in its immediate vicinity, as well as from the transport of hazardous products. The location of three plants with a high risk of a serious industrial accident (Onico Gas Sp. z o. o. in Planta, PERN S.A. Fuel Base No. 15 in Narewka and Bałtykgaz Sp. z o. o. in Zabłotczyzna) and the 2. Regional Logistics Base - Hajnówka Depot on an area of 625 ha creates an additional threat to the forest. A spreading forest fire, on the way of which the above-mentioned facilities are located, may not only pose a real threat to those facilities, but in such a situation the dynamics and intensity of combustion may increase as well as the size of the zone covered by the fire.

Due to the increased number of fires in the Białowieża Forest caused by power line failures, including tree falls and broken wires, compared to the rest of the country, it is recommended to first cut down standing dead trees that bring about a fire hazard, and then to leave them on the ground. Consideration should also be given to laying a power line underground.

Map 7 shows places of potential threat caused by factors other than habitat conditions.

2. Białowieża Forest Fire Protection Plan

Forest fire protection in Poland is regulated by *the Regulation of the Minister of Internal Affairs and Administration of 7 June 2010 on fire protection of buildings, other construction objects and areas (Journal of Laws of 2010, No. 109, item 719, as amended) and the Minister of the Environment of 22 March 2006 on detailed principles of forest fire protection (Journal of Laws of 2006, No. 58, item 405, as amended).* The above regulations apply to the preparation of forest areas in the event of fire and minimizing its potential effects by creating fire protection infrastructure appropriate to the existing threat. The document regulating fire protection in the State Forests National Forest Holding based on applicable legal acts is the *Forest Fire Protection Instruction*.

Fire protection in the Białowieża Forest is specified in the *forest management plans of the Białowieża, Browsk and Hajnówka Forest Districts for 2012-2021, the Protection Plan of the Białowieża National*

Park and the Methods of Action in the Event of a Forest Fire prepared by the forest districts and the Park, which are updated every year, as well as the *Rescue Plan of the Hajnówka District* prepared by the District Headquarters of the State Fire Service in Hajnówka.

2.1 Forecasting forest fire hazard for the Białowieża Forest

During the fire season (March–September), the State Forests monitor the forest fire hazard in Poland using an automated network of meteorological measurement points. Every day at 9:00 and 13:00 the forest fire hazard level (pl. stopień zagrożenia pożarowego lasu – SZPL) is determined for 60 forecast zones based on the measurement of meteorological parameters (air temperature, relative air humidity, precipitation) and pine litter moisture. Air temperature above 24 °C, relative air humidity below 40%, no precipitation and none or little cloud cover are the parameters that determine the so-called fire weather, during which over 60% of forest fires occur. Using the COSMO numerical weather forecast model, the forecasted SZPL is also determined up to 24 hours in advance. The forest fire hazard level determines daily fire protection activities undertaken by the forest service and other services responsible for fire safety. The tasks and protective measures carried out by the organizational units of the State Forests depending on SZPL are specified in the *Forest Fire Protection Instruction* – Table 16.

Table 16. Protective tasks and projects carried out by organizational units of PGL LP depending on the level of forest fire risk

No.	Type of activity	SZPL			
		0	1	2	3
1.	Maintaining duty at the alarm and dispatch point (PAD) of the Regional Directorate of the State Forests (RDLP)	x	x	x	x
2.	Maintaining duty at the PAD of the respective forest district	x[1)]	x[1)]	x	x
3.	Performance of tasks by the RDPL director's representative	x[2)]	x[2)]	x	x
4.	Performance of tasks by the forester's representative	x[3)]	x	x	x
5.	Observers on duty at fire lookouts and other observation points	x[1)]	x	x	x
6.	Ground patrolling in areas at enhanced risk of fire	–	–	–	x[3)]
7.	Launch of air patrols	–	x[2)]	x[2)]	x[2)]
8.	Introduction of a state of emergency for immediate use of mechanical and household equipment along with its handling	–	x[3)]	x[3)]	x[3)]
9.	Introduction of duty for the local forest service	x[4)]	x[4)]	x[4)]	x[4)]
10.	Launch readiness time* for firefighting aircraft [min.]	–	**15**	**10**	**10**
11.	Coordination of all activities by RDLP	x	x	x	x
12.	Introduction of duty of patrol and fire-fighting vehicles' staff	x[3)]	x[3)]	x	x

Legend:

x – corresponds to performance of activities,

x[1)] – the respective forest district inspectorate – in cooperation with RDLP – fixes the time of duty or cancels it,

x[2)] – according to the principles defined by the director of RDLP,

x[3)] – according to the rules defined by the forest manager,

x[4)] – depending on local weather conditions,

* –take-off readiness time – the time (in minutes) from requesting the aircraft to take off.

By way of Ordinance no. 5 of the Director General of the State Forests of 31 January 2018 on the introduction of a new division of forest areas in Poland into forecasting zones (ZO.2621.5.2017), a new forecasting zone 1-E was created, covering the following Forest Districts: Białowieża, Bielsk, Browsk, Hajnówka, Nurzec and Rudka and the Białowieża National Park – Figure 10. The purpose thereof was to increase the accuracy of determining the level of forest fire risk by reducing the area of the forecasting zone and locating three meteorological measurement points within it (the forecasting point in the Bielsk Forest District and auxiliary points in the Hajnówka and Rudka Forest Districts).

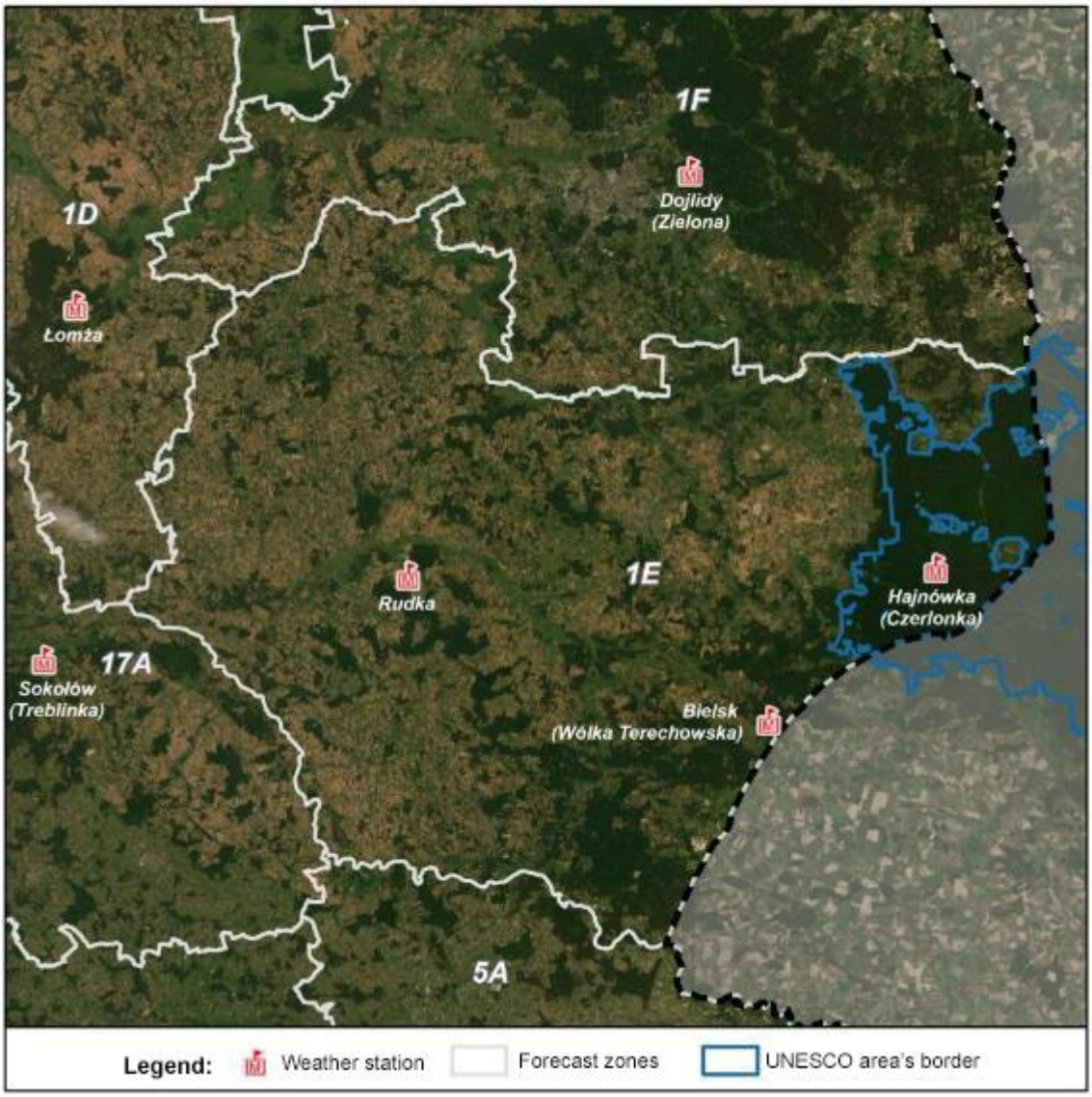


Figure 10. Range of the forecasting zone 1-E

Previously, the forecast zone used to cover 13 forest districts, and the forecast point used to be located in the Dojlidy Forest District, 80 km from the Białowieża Forest. As a result, the determined level of threat (and, consequently, the protective measures taken) was not always adequate to the actual fire risk in the Białowieża Forest, especially in unstable weather conditions. The current organization of the fire threat monitoring system for the Białowieża Forest has increased the accuracy of determining

SZPL, taking into account local conditions, and has made protective measures more appropriate to the threat level, which contributes to strengthening the fire protection system of the Forest.

2.2. The Forest Fire Detection System

In accordance with the *Regulation of the Minister of the Environment of 22 March 2006 on detailed principles of forest fire protection and the Forest Fire Protection Instruction*, organizational units of the State Forests are obliged to create and maintain an observation and alarm system, the task of which is to detect a fire in the forest as quickly as possible, determine its location and alert the forces and means to extinguish the fire.

A network of permanent ground observation is the basic method of detecting forest fires. This network is made up of objects which make it possible to observe forest areas in order to detect fires and transmit information about their detection. This function can be performed by fire observation points (observation and television towers) and substitute observation points located on other tall buildings (skyscrapers, church towers, water towers, etc.). Forest observation in order to detect fire is required in forest districts of the I and II category of forest fire hazard. On the other hand, in forest districts of the III category, which according to the applicable regulations includes the area of the Białowieża Forest, observation is organized depending on local needs. The range of effective observation from an observation point is assumed to be within 10–15 km, depending on the height of the facility, topography and local air transparency. The design of the observation network for the area of the regional directorate of the State Forests takes into account the boundaries of forest complexes rather than the administrative boundaries of forest districts and the regional directorate.

All forest areas are monitored from observation points, regardless of their form of ownership. Forest observation from observation points is organized by the respective forest district. It is carried out during the day in the fire hazard period, on days with the 1st, 2nd and 3rd degree of forest fire hazard.

Even though forest fire protection regulations do not impose an obligation to organize a fire detection system, the area of the Białowieża Forest, due to its unique character, has been subject to television surveillance.

The observation system in the Białowieża Forest includes television towers in the Browsk and Hajnówka Forest Districts. To a small extent, the Białowieża Forest is also observed from observation points located in the Bielsk and Żednia Forest Districts. When analyzing the degree of coverage of the Forest area by effective observation, it should be stated that it is fully sufficient. About 74% of the forest area of the Białowieża, Browsk and Hajnówka Forest Districts and the Białowieża National Park is located less than 10 km from the nearest observation point, and in the case of forests included in the UNESCO area, this percentage is almost 77. If we take into account that the effective observation radius is 15 km, then 99.6% of the area is within the range of visibility of the observation point, while for forests included in the UNESCO area it is 99.9%. The coverage of the Białowieża Forest area by television cameras is shown on map 8. Observation from fixed points should be supplemented by ground

patrolling in order to supervise the safe behaviour of people staying in the forest. Such patrols should be organized during periods of increased fire risk (2nd and 3rd SZPL) in areas most frequently visited by people during their stay in the Białowieża Forest. This applies in particular to tourist trails and the vicinity of places attractive to tourists.

2.3. Alarm and communication system

According to the Forest Fire Protection Instruction, organizational units of the State Forests create and maintain alarm and dispatch points (PAD) and provide technical conditions for their continuous operation. PADs are established at the level of the regional directorate of the State Forests (regional PAD), for a group of forest districts (district PAD - created if necessary) or a single forest district (basic PAD). The basic PAD is organized in forest districts I and II KZPL. In forest districts III KZPL, PADs are organized if necessary. In accordance with Ordinance No. 8/2019 of the Director of the Regional Directorate of State Forests of 11 March 2019 on conducting direct action in forest fire protection in 2019. (ZO.26205.5.2019) the Forest Districts: Białowieża, Browsk and Hajnówka were obliged to run alarm and command points according to the principles for the forest districts II KZPL. Such an organization system should be maintained in the subsequent years. A PAD also operates in the Białowieża National Park. PADs have a specific alarm plan and schedules of fire duty of the unit management and forest service during the direct action period, i.e. from March to October. The basic tasks of the PADs of forest districts and of the Białowieża National Park include:

1. implementation and coordination of protective tasks and activities depending on SZPL;
2. supervision over the functioning of the observation and alarm system in the subordinate area and management of its work;
3. during periods of so-called fire weather, preparation of a forecast of fire spread, based on meteorological data, using the "Forest Fire Model" application;
4. determination of the location of the fire reported by the observation network;
5. notification of the fire to the Command Post of the District Commander of the State Fire Service in Hajnówka;
6. notification of the fire to the management of the forest district or park of the regional PAD and the appropriate local service,
7. sending forces and resources at the disposal of the forest district or park to the fire;
8. reporting the need for forces and resources at the disposal of the regional directorate of the State Forests;
9. maintaining communication with the place of fire extinguishing.

The PAD dispatchers of the Forest Districts and of the Białowieża National Park have specific procedures in place in the event of a forest fire, aimed at alerting as soon as possible the Command Post of the District Commander of the State Fire Service which has the forces and means to extinguish the fire. The alert plans contain a list of the notified rescue services, persons from the unit management,

forest service, forest guard and park guard, along with the emergency telephone numbers and radio codenames.

The emergency communication network in the forest districts is based on radio communication, which is supplemented by a landline and mobile telephone network. Radio communication is carried out using 3 base stations, 5 mobile radios operating in the LP network and 12 wearable radios enabling communication at the action site on the Ministry of Interior's services cooperation channel - B 112, allowing for communication with fire protection units at the site of the extinguishing action. The Białowieża National Park has only landline and mobile telephone communication measures. According to the Forest Fire Protection Instruction in forest districts included in the III KZPL the provision of radio equipment depends on local needs.

The radio communication system currently in operation in the forest districts, as well as the mobile telephone system used in the Białowieża National Park, do not provide adequate quality of alarm and communication possibilities and do not guarantee full coverage of the entire Forest. There are areas where communication is limited or completely absent. The use of the mobile telephone network poses a major problem, not only due to the absence of communication in some areas of the Forest, but also, especially in the border region, due to the overlap of the signal from the Belarusian operator's transmitters, as there is a drastic increase in the cost of conversations. Therefore, efforts should be made to ensure communication for fire-fighting purposes in the entire Białowieża Forest, which is associated with necessary financial investments and a new communication organization, which is currently being started in the State Forests. Its implementation should be seen as a future decisive improvement in the functioning of the communication and alarm system.

2.4. Extinguishing equipment

The Regulation of the Minister of the Environment of 22 March 2006 on detailed principles of forest fire protection states that a forest district or national park is obliged to create at least one base with equipment for extinguishing forest fires. The regulation also specifies the equipment standard dependent on the KZPL. The equipment base of a forest district or national park included in the III KZPL should be equipped with: 10 backpack fire extinguishers or water jets, 10 spades (shovels), 10 mufflers and a plough for digging fire protection strips. The forest fire protection instructions allow for equipping forest districts with other equipment and devices and extinguishing agents according to the needs of the forest district. It is the competence of the head of the regional directorate of the State Forests, depending on the KZPL RDLP and other factors influencing the fire hazard of large forest complexes, including for the needs of organizing regional firefighting operations, to determine additional equipment for the equipment bases of forest districts with other necessary equipment and devices. The equipment may be deployed in more than one place within the territorial scope of the forest district in consultation with the District Commander of the State Fire Service.

The Director General of the State Forests, in consultation with the directors of the regional directorates of the State Forests, makes decisions regarding the rental of the number and types of aircraft used for extinguishing forest fires and patrolling forest areas.

The list of equipment bases with the equipment type and quantity is included in Table 17, and their location is shown on Map 7.

Table 17. List of extinguishing equipment bases

Unit	Location	Equipment list (pcs)						
		Fire extinguishers	Spades / łshovels	Mufflers	Hoes	Hoe axes	Axes	Hand-pump extinguishers
Białowieża Forest District	Forest Inspectorate, ul. Wojciechówska 4	13	40	20	10	8	8	3
	Podcerkiew Forest Sub-inspectorate, Podcerkiew Settlement	5	40	10	5	-	8	7
Browsk Forest District	Browsk Forest Inspectorate	10	20	10	30	-	10	10
	Pasieki Forest Sub-inspectorate, Pasieki Settlement	-	20	-	10	-	5	-
	Lewkowo Forest Sub-inspectorate Gruszki 18 Settlement	-	20	-	10	-	5	-
	Jelonka Forest Sub-inspectorate Jelonka Settlement	-	20	-	10	-	5	-
	Nowosady Forest Sub-inspectorate Sorocza Nóżka Settlement	-	20	10	10	-	5	-
	Gnilec Forest Sub-inspectorate Gnilec Settlement	-	20	-	10	-	5	-
	Rybaki Sub-inspectorate Podwaśki Settlement	-	20	-	10	-	5	-
Hajnówka Forest District	Sacharewo Forest Sub-inspectorate	9	20	10	-	-	-	10
	Łozice Forest Sub-inspectorate	-	20	-	10	-	8	-
BPN (Białowieża National Park)	Sierganowo Forest Sub-inspectorate		30	10	6	4	10	
	Zamosze Sub-inspectorate		48		20	10	10	10
Total	-	**37**	**338**	**70**	**141**	**22**	**84**	**40**

According to the data in the table above, the standard for portable equipment in forest districts and the BPN is in line with the applicable regulations, and in the case of some types of equipment it exceeds them. Portable equipment should be used to a greater extent to extinguish fires in the soil cover, especially in reserves and in areas where the subject of protection are ground cover plants.

In addition to portable equipment, the forest districts and the BPN have devices for ploughing strips, four light patrol and firefighting vehicles with a 400 l water tank and a 50 l/m pump with a quick-

attack reel, as well as portable firefighting equipment. The BPN is equipped with three foldable water tanks with a capacity of 2000 l each.

Two firefighting aircraft at the disposal of the Regional Directorate of the State Forests in Białystok can be allocated for the purposes of carrying out firefighting operations from the Forest Air Bases. One of them can be found at the Krywlany base, 65 km away from the Białowieża Forest in a straight line, while the other - at the Rostki base, 170 km away. Firefighting flights can be performed by aircraft from the operational landing field on the edge of the Forest in the town of Narew, which is the private property of the "Pronar" company, with which the Regional Directorate of the State Forests in Białystok signed an agreement on the possibility of using it for rescue purposes.

It would be worth considering, in consultation with the relevant local organizational units of the State Fire Service when planning their additional equipment with firefighting devices, the possibility of purchasing equipment particularly useful for conducting firefighting operations in difficult forest conditions, e.g. off-road firefighting vehicles, foldable water tanks with a capacity of at least 8,000 l, a high-performance pump, a vehicle for moving in difficult conditions, such as an "all-terrain vehicle" or a quad. It is also possible to consider co-financing of the purchase of equipment useful for extinguishing forest fires by volunteer fire brigades.

2.5. Fire access roads

Fire access roads constitute the basic communication network of the forest complex in planning and organizing rescue operations. The course of fire access roads should be compatible with the remaining communication network of the forest complex, regardless of the owner or manager of the forest. Fire access roads should be marked in a way that allows their identification, and their passability should be checked on an ongoing basis.

In accordance with the current *Regulation of the Minister of the Environment of 22 March 2006 on detailed principles of forest fire protection*, the distance between any point located in the forest and the nearest public road, excluding motorways and expressways, or fire access road, should not exceed 1,500 m for forests classified in fire hazard categories II and III.

The starting point for creating a network of fire access roads is the public road system. 84.16 km of public roads run through the areas of the forest districts of the forest and they are managed by: provincial, district and municipal authorities.

In the central part of the Białowieża Forest, the provincial road no. 689 (W-E route) divides the Hajnówka and Białowieża Forest Districts into two parts, connecting the towns of the same name. It runs through forest areas along its entire length. It is the main communication artery in the Białowieża Forest, which is of strategic importance for public safety. This route with high traffic intensity is maintained in a good technical condition. This road is the basis of the internal forest road system and allows access to nine fire access roads. On the western side of the Białowieża Forest, outside the forest lands, runs the provincial road no. 685 (N-S route). The route allows residents of the Białystok

agglomeration to access the Białowieża Forest. In the town of Nowosady it intersects with the provincial road no. 687. It allows access to one fire access road. The provincial road no. 687 runs through the northern part of the Białowieża Forest, exclusively through the Browsk Forest District. It allows access to fire access roads in three places. On these roads, other public roads with a hardened surface and railway tracks, in accordance with the requirements of § 39, sec. 1 *of the Regulation of the Minister of Internal Affairs and Administration of 7 June 2010 on fire protection of buildings, other construction facilities and areas* (Journal of Laws of 2010, No. 109, item 719, as amended)*, i.e.: at a distance of less than 30 m from the edge of a railway track or a public road, with the exception of a road with an unpaved surface, it is forbidden to leave in particular branches, brushwood, unpruned cut trees and post-operation waste.* It is not permitted either to store these remains in the form of embankments and piles.

The previously mentioned condition regarding the density of public roads is met for 45% of the Forest area. In the case of forests included in the UNESCO area, access from public roads is provided for 39% of its area. The coverage of the public road network is similar for all flammability classes and corresponds respectively to: 41% - for class A stands, 49% - for class B stands and 42% - for class C stands. The coverage of the communication network in the Białowieża Forest is shown on map 9.

In the Białowieża Forest districts 53 fire access roads were designated with a total length of over 330 km, numbered uniformly in all three forest districts and in the Białowieża National Park (access roads running through more than one organizational unit have the same number along their entire length). The largest number of access roads was designated in the Browsk and Hajnówka Forest Districts – approximately 100 km each. In the Białowieża Forest District, approximately 83 km were designated, and in the Białowieża National Park - 33 km. In the case of designating new access roads (understood as the use of existing forest roads, not the construction of new ones), uniform marking must be ensured.

The condition concerning the density of fire access roads is met for 85% of the Forest area. In the case of the UNESCO area, this condition is met for 90% of the area. The coverage of the fire access network is similar for all flammability classes and is respectively: 81% - for class A stands, 85% - for class B stands and 87% - for class C stands.

Taking into account the network of public roads and fire access roads, the condition of the maximum distance of 1,500 meters is met for 95.2% of the forest area of the Białowieża Forest - respectively: 97.4% - in class A, 96.6% - in class B and 93.6% - in class C. On the other hand, the coverage of the communication network for the UNESCO area is 94.9%. For the forest areas of the Białowieża Forest, this coverage is about 99%. Only in the Białowieża National Park it is significantly lower (74%) and varies depending on the flammability class of the stands.

For the most flammable stands classified as class A, it is similar to that in the forest districts (92%). For stands of other classes, it is lower and amounts to 76% for class B and 71% for class C. The vast majority of stands not covered by the fire access network are located in the strict protection zone of the Białowieża National Park.

The analysis of the distribution of fire access roads and the general preparation of forest complexes for firefighting operations reveals that the area is not fully accessible for firefighting purposes. This analysis does not include roads in the BPN area, because they do not constitute fire access roads under the applicable regulations. Table 18 presents the results of the field inventory of the condition of fire access roads.

Table 18. Condition of fire access roads – results of the inventory conducted in 2019

Feature	Variables	Number of sections	Length [km]	[%] of total
Surface	Hardened	32	13.2	4.6
	Improved ground surface	330	142.4	50.2
	Unimproved, profiled soil	207	84.7	29.9
	Unimproved, natural, unprofiled	112	43.3	15.3
Condition	Good	162	66.3	20.9
	Satisfactory	259	132.1	41.7
	Average	263	115.2	36.4
	Poor	11	3.3	1.0
Width	>7.0 m	80	40.0	13.4
	5.0 – 6.9 m	164	75.1	25.1
	3.0 – 4.9 m	443	182.1	61.0
	<3,0 m	1	1.4	0.5
Trafficability for heavy equipment	Yes	693	316.0	99.7
	No	2	0.9	0.3

The predominant share of dirt roads, improved, in satisfactory technical condition, wider than or equal to 3.0 m is visible. Sections that are impassable, narrow and in a poor technical condition constitute a minority; however, due to the function performed by the designated roads, these sections should be improved first.

The network of fire access roads, similarly to public roads, in the Białowieża Forest shown on map 8 has been classified into the following 4 classes:

1 – classified as passable access roads with a good road surface condition and width >= 5 m,

2 – classified as passable access roads with a good road surface condition and width < 5 m and access roads with an average or satisfactory road surface condition and width >= 3 m,

3 – classified as passable fire access roads with width < 3 m and access roads with a poor road surface condition, as well as access roads classified as impassable,

4 – access roads with unspecified condition.

Taking into account the simultaneous coverage of the Forest area with a network of public roads and fire access roads classified as classes 1 and 2, the condition of the maximum distance of 1500 m is met for 58.8 thousand ha, which constitutes 93.1% of its forest area. This coverage is ensured, respectively: for the area 95.8% - in class A, 95.3% - in class B and 90.8% - in class C. The coverage of

the UNESCO area with the communication network is 92.6%. The distribution of fire access roads according to the 4 aforementioned classes is presented on map 10.

The analysis of the coverage of forest areas by the network of public roads and fire access roads and the assessment of their technical condition do not yet provide full information on the communication accessibility of a given area for fire brigade units. In this case, the location of fire brigade units in relation to forest complexes and the calculation of the time of arrival and commencement of firefighting operations are important. For this purpose, based on data on the location of fire protection units, public roads and fire access roads, the estimated time of commencement of firefighting operations from the moment of alarm was determined. This time was established as the sum of the departure time, arrival time calculated on the basis of the road network analysis and the time of deployment of firefighting units, calculated on the basis of the distance from the public road - fire access road. In the road network analysis, it was assumed that the vehicle speed would be 60 km/h for provincial roads, 40 km/h for other public roads and selected fire access roads (Narewka and Zwierzyniecka roads to Budy), and 20 km/h for other fire access roads. The deployment time was calculated based on the distance of individual stands from public roads or fire access roads in 5-minute increments, corresponding to a distance of 400 m. To simplify the calculations, it was assumed that the State Fire Service units leave immediately, while the volunteer fire brigade units do it with a delay of ten minutes. The results of the calculations of the travel time are presented on map 11.

Based on the analysis of the data presented on this map, two areas with poor transport accessibility can be identified. These are the areas on the southern edge of the Polish part of the Białowieża Forest in the territory of the Przewłoka settlement and the strict protection area of the Białowieża National Park. The map also shows the course of public roads and fire access roads and highlights some of the access roads (access roads no. 8, 20, 22 and 27 and partially no. 11, 14 and 15) whose technical parameters should be improved. On these access roads, works should be carried out first to increase the speed to at least 30 km/h (removal of bushes reducing the road clearance and blocking passing places, leveling of the surface), which will shorten the travel time in this area by 10 minutes. This procedure also applies to other fire access roads, but it will only be carried out in a strip of 50 m from the road, in accordance with the recommendations of the UNESCO mission from 2018.

Next, it is recommended to undertake works aimed at maintaining the appropriate technical parameters of fire access roads to enable their use by emergency vehicles, in accordance with the requirements contained in the Regulation of the Minister of the Environment of March 22, 2006, on detailed principles of forest fire protection (Journal of Laws of 2006, No. 58, item 405, as amended). These works should be carried out first on fire access roads to forest areas classified as flammability classes A and B. They should particularly address sections whose current technical condition or geometric parameters may impede the efficient passage of firefighting vehicles. In subsequent stages, fire access roads designated from the existing road infrastructure network should be successively adapted to the required parameters. The technical condition of access roads should be verified annually

before the start of the direct response season and each time adverse weather conditions occur, such as precipitation or strong winds.

In places where a fire access road connects with a public road, the visibility of the road with priority of passage should be ensured, enabling the drivers to decide whether
to perform the intended maneuver or to stop before the intersection. It is recommended to remove obstacles limiting the field of visibility at exits from public roads. In the case of a road without passage, a maneuvering area with dimensions of at least 20 x 20 m should be provided to allow for turning. The existing network of access roads, together with newly created ones, should be clearly and uniformly marked throughout the entire Białowieża Forest and included in the updated *Methods of action in the event of a forest fire*. It is recommended to mark the access numbers in red against a white square painted on a tree – Figure 11. The markings must be visible at exits from public roads, intersections of fire access roads and must confirm the relationship within the forest complex. This method of marking requires less work during maintenance operations. An important task is to ensure their constant visibility. The condition of the neighboring vegetation should be regularly checked to uncover the markings if necessary. If needed, repaint them so that they constitute legible content that stands out against the forest background. Information on the course of fire access roads should be updated in the resources of the forest numerical map.

Figure 11. Proposed marking of fire access roads (e.g. on characteristic trees)

2.6. Water supply for fire extinguishing purposes

Water supply for the purposes of protecting the forest complex against fire corresponds to natural and artificially prepared water resources adapted for water collection using fire-fighting equipment. Artificial water resources include: covered and uncovered reservoirs, hydrants and deep wells. Adaptation of water resources for fire-fighting purposes consists of:

a) preparing access roads to water intake locations, starting from public roads or fire access roads,
b) building intake wells or other devices at intake locations to facilitate water collection by firefighting equipment,
c) securing intakes against contamination and silting,
d) preparing maneuvering areas at water intake locations with dimensions of at least 20 × 20 m or a loop bypass in the case of a road without passage,
e) ensuring the possibility of collecting water from locations no more than 4 m deep, counting from the pump axis,
f) building appropriate gates on streams, ditches and drainage channels.

The amount of water for extinguishing purposes should be at least: 50 m3 from a natural or artificial reservoir and 10 dm3/s from a hydrant, watercourse or deep well. The beginnings of access roads to water intakes should be marked obligatorily, and their further course - according to needs. The designated place of water intake - water position should be marked.

In accordance with the current *Regulation of the Minister of Internal Affairs and Administration of 7 June 2010 on fire protection of buildings, other construction facilities and areas*, as well as the classification of the Białowieża Forest area into the III category of fire hazard, water resources for fire extinguishing purposes should be agreed with the locally competent District Commander of the State Fire Service. The network of surface waters, which naturally constitute reservoirs for water intake for fire extinguishing purposes in the Białowieża Forest, consists of: the Siemianówka reservoir (at the maximum level of accumulation, the reservoir holds 79.5 million m^3 of water collected on an area of 32.5 km^2), the Topiło artificial reservoir and numerous watercourses (streams and rivers): Narew, Narewka, Łutownia, Perebel, Jabłonówka, Jelonka, Braszcza, Hwoźna, Dubilka, Krynica and others. The observed decrease in groundwater levels in the Białowieża Forest, especially during periods of drought, limits the availability of water in natural reservoirs, which is why the designed water supply network should take into account places where water for fire extinguishing purposes will be constantly available. The possibility of improving the availability of water in natural watercourses is provided by conducting small retention works, which to some extent and locally may contribute to reducing the fire hazard.

Water supply for fire extinguishing purposes in accordance with the *Methods of action in the event of a forest fire* developed for forest districts and the Białowieża National Park is to be provided by 99 water draw-off points. In order to assess the water supply of the forest areas of the Białowieża Forest, all points were classified into one of 5 categories:

- hydrants,
- open points with very large water resources,
- open points with a capacity of about 100 m3,
- draw-off points on the Narewka River,
- draw-off points on smaller watercourses.

An assessment was also made for the technical condition of those points on a three-point scale (good, average and poor). The list of types of points and their technical condition is presented in Table 19.

Table 19. Draw-off points broken down by categories

Type of point	Technical condition				Total
	Good	Average	Poor	Unspecified	
Hydrant	20	7		41	68
open points with very large water resources	3	1	2	1	7
open points with a capacity of about 100 m3	6	4			10
draw-off points on the Narewka River	6				6
draw-off points on smaller watercourses	3	5			8
Total	**38**	**17**	**2**	**42**	**99**

The analysis of the number and type of water draw-off points alone is not enough, as it does not take into account their spatial distribution. Assuming the exaggerated requirements as adopted for the II KZPL forest districts, one point can service an area of 7,850 ha, and in the analyzed area one point falls on about 1,000 ha, so there are much more points than the regulations require. However, their distribution is uneven and only an analysis of the distances of all forests from water draw-off points allows for an assessment of water supply (map 11). Out of all forest complexes, about 97% of the area is located less than 5 km from the nearest water draw-off point, with no significant differences between flammability classes. Forests that do not fit within the 5 km buffer from water draw-off points form three complexes. The largest of them, with an area of almost 1,200 ha, is located in the eastern part of BPN in the strict protection zone. The second one, much smaller, with an area of approximately 400 ha is located on the southern edge of the Białowieża Forest near the border of the Białowieża and Hajnówka Forest Districts. The last, smallest one, with an area of slightly over 200 ha is located on the western edge of the Forest at the border of forest complexes in the vicinity of the towns of Orzeszkowo, Sosnówka and Wygon. Although this area is located more than 5 km from the water draw-off points designated in the *Methods of action in the event of a forest fire*, in these towns there is a hydrant network and this area should be considered covered by a water supply network. Taking into account that only 13 points are located on large open reservoirs or on the Narewka River, which provide an adequate water supply in the event of long-term fire-fighting operations and can operate as strategic water draw-off points, a detailed analysis of their location and condition was carried out (map 12, 13). In this case, for distances up to 5 km, the coverage of forest complexes with a network of water draw-off points is much smaller and amounts to 52% for all forests and 54% for forests included in the UNESCO area. The coverage is highest for class A stands and lowest for class C ones. For all forests, it amounts to: 58% in flammability class A, 53% in B, and 50% in C. For the UNESCO area, it amounts to: 56% in class A, 56% in B and 51% in C. Large, inexhaustible water draw-off points should be planned in case of exhaustion of local water resources. Hence, calculations of additional coverage were made for a distance of 10 km.

In this situation, for all forests, the coverage is 96%, while for the UNESCO area - 97%. The only larger forest complex not covered in this case by a network of water intake points is located in the

immediate vicinity of Hajnówka, where water resources can be replenished from the municipal hydrant network. Analyzing the coverage in terms of individual flammability classes for all forests, it is: for flammability class A - 99%, for class B - 95%, and for class C - 96%. For the UNESCO area, respectively: 100%, 98% and 96%.

The use of chemical extinguishing agents should be limited only to biodegradable agents and those necessary to eliminate fires that are difficult to extinguish with water, e.g. subsurface fires (muck, peat).

2.7. Fire protection zones (strips)

In accordance with § 38.1. of *the Regulation of the Minister of Internal Affairs and Administration of 7 June 2010 on fire protection of buildings, other construction facilities and areas (Journal of Laws of 2010, No. 109, item 719)*, forests located near objects that may pose a fire hazard to the forest are separated from these objects by fire protection strips maintained throughout the year. Forest areas classified in III KZPL have been excluded from this obligation. At the same time, § 39.1. states that at a distance of less than 30 m from the edge of a railway track or a public road, with the exception of a road with an unpaved surface, leaving in particular branches, brushwood, unpruned cut trees and post-operation waste, is prohibited.

Fire protection strips in the Białowieża Forest are maintained near railway lines, industrial facilities, in some areas of the area division (Hajnówka Forest District, Starzyna District), near the 2. Regional Logistics Base Hajnówka Depot and tourist development sites.

2.8. Preventive actions

The *forest management plans of the Białowieża, Browsk and Hajnówka Forest Districts for the period from 1 January 2012 to 31 December 2021* specified preventive tasks in the field of fire protection. The general directional action was assumed to be the need to manage forestry in such a way as to increase the biological resistance of tree stands to the occurrence and development of forest fires. This goal is to be achieved through actions and activities reducing the amount of easily flammable materials in the forest and hindering the spread of fires. It was recommended to introduce undergrowth, admixtures of deciduous trees and shrubs, especially along roads, maintain ecotone zones on the field-forest border and on the edges of the forest adjacent to wide roads in the form of bush belts, low trees and a loose upper layer, and maintain the appropriate density and condition of forest roads. Other recommended preventive actions included educating the public and directing tourist traffic. It was pointed out that it was necessary to conduct a propaganda campaign on fire protection among the local community, addressed to adults, youth and children. The following actions were also recommended:

- hanging up posters and announcements with educational content in places where people gather, e.g. in front of shops, offices, next to State Forests buildings;

- placing information and warning boards in places with the greatest human penetration and along roads leading to the forest;
- enforcing the ban on moving around forest areas during periods of the greatest fire risk;
- using the media to communicate information to the largest possible number of recipients during periods of the greatest risk.

It should be reminded that the forest management plans were prepared in 2011 and they did not take into account the situation that occurred in mid-2012. The emphasis in the field of prevention should be put on social education and therefore it is recommended to prepare an information and warning campaign about the existing fire hazard in the Białowieża Forest, aimed at making people arriving there aware of the threat, also covering the rules of proper conduct in the forest which does not pose a risk of starting a fire. Contrary to appearances, the basic principle that "prevention is better than extinguishing" is often forgotten and the importance of educational and information activities, mostly due to the lack of their immediate effect, are put on the back burner, or even omitted in favor of exclusively preparing forest areas for a possible fire. An effective educational and information campaign should be professionally planned, conducted in the long term and addressed. Among its recipients, the local community, which visits the Forest on a daily basis, should be particularly important. It is necessary to present the problem of the growing fire hazard in the Białowieża Forest as a part of the current work of educators and administrators of the websites or Facebook profiles of forest districts. The aforementioned preventive actions will be continued in the next decade.

As a part of the implementation of the Forest Fire Protection and Extinguishing Plan for the Polish part of the Białowieża Forest Transboundary World Heritage Site, it is recommended to implement educational activities whose purpose is to make both the local community and tourists aware of the fire hazard in the Białowieża Forest and popularize the principles of safe conduct in the forest. An effective educational and information campaign should be professionally planned, conducted in the long term and addressed to various social groups, among which the local community that interacts with the Forest on a daily basis should be particularly important. It is recommended to present the existing problem of fire hazard, especially during the period of increased forest flammability (March - September), taking into account the high level of forest fire hazard (3.SZPL), on the websites of forest districts and the park, on official Facebook profiles, in local media and in the work of forest educators.

3. Modeling the spread of forest fires in the Białowieża Forest

The "Forest Fire Model" application was used for modeling of the spread of fires in the Białowieża Forest. It was developed at the Forest Research Institute based on laboratory and field studies on the conditions of the formation and spread of experimental and real fires. It allows for calculations to be made for a fire of litter, grass and heather cover, as well as for entire stand fires. The model allows for forecasting the speed of the fire front and its area and perimeter depending on: time, wind speed, moisture content of the combustible material and fire load. It also allows for calculating the amount of

water or foam needed to extinguish the fire, depending on the selected tactical variant of extinguishing operations (extinguishing the entire fire surface, its perimeter or location using barrier strips). Some of the model calculations were performed directly on the layers of numerical maps based on the equations used in the software.

For the purposes of modelling, it was necessary to determine the probable type of fire and to specify the conditions for which calculations would be performed. For this purpose, the type of fire was determined for each of the separated areas. Since the share of stands younger than 20 years of age in the Białowieża Forest, in the case of which there is a high probability of a cover fire transforming into a total fire, is very small (smaller than 1%), it was assumed that calculations would be performed only for soil cover fires. This assumption is also confirmed by the fact that no total fire has been recorded in the Białowieża Forest in the last twenty years. In the part belonging to the UNESCO area, there are also no stands with heather cover. Approximately 580 hectares of such stands described in section 1.4.3 are located to the north of this area. Therefore, it was assumed that one of two types of soil cover fire will be assigned to each separated area. The separated areas in which a grass cover fire will occur were assumed to be those which in the valuation description have herbaceous, sodden, heavily sodden and heavily weeded cover, as well as those in which the occurrence of vegetation posing a threat (grasses, ferns) and non-forested areas (bogs, meadows, pastures, hunting plots) was found during the inventory. The remaining separated areas were classified as those in which a litter cover fire will break out. In addition, it was assumed that on surfaces such as roads, rivers, ditches, built-up areas, border strip, the fire will not spread - the area and perimeter were not calculated. The fire types adopted for model calculations, generalized to the department level for the purpose of improving readability, are shown on Map 14.

The basic parameters needed to calculate the area and perimeter of a fire are the humidity of the combustible material, the wind speed and the time of free fire development (from the outbreak of the fire to the commencement of extinguishing actions). In fully dense stands, the wind speed in the stand is approximately 0.4 times the existing wind speed. However, in the Białowieża Forest, in a large part of the separated areas, the stands have disintegrated, which means that the wind speed in a stand is closer to the existing wind speed. The most unfavourable scenario was adopted for model calculations. For stands without spruce, 0.4 times the existing wind speed was assumed, in non-forest areas (bogs, wastelands, fields, ecological land) the existing wind speed was assumed, while for stands with spruce it was assumed that they would disintegrate completely. Therefore, the wind speed in the stand was calculated in accordance with the following formula:

$$\textit{the existing wind speed} \times(0.4+0.05 \times \textit{spruce share \%})$$

The ratio of wind speed in the stand to the existing wind speed (wind speed index) generalized to the level of the divisions is presented on map 15.

Then, for each of the separated areas, in accordance with the previously determined type of fire

and wind speed, taking into account the correction resulting from the value of the wind speed index, calculations of the fire area and perimeter were made after the time of free development.

The time of free development was assumed to be the time of arrival and deployment of fire brigade units discussed in chapter 2.5. plus 20 minutes. These 20 minutes is the estimated time from the moment of the outbreak of a fire to its detection and alarming of the fire brigade. All calculations were made for three variants of meteorological conditions:

- litter humidity 12% and existing wind speed 5m/s
- litter humidity 12% and existing wind speed 2m/s
- litter humidity 20% and existing wind speed 2m/s

The predicted fire sizes were then classified into five classes presented in Table 20. These classes were established on the basis of model calculations of the required amounts of forces and extinguishing agents necessary to localize a fire (stop its spread) for normal commercial stands. In the case of the Białowieża Forest, where the fire load of grass vegetation and dead wood is much higher, these amounts will be about three times bigger for grass cover fires and more than five times bigger for fires in places with lying dead wood, especially in the 1st and 2nd decomposition classes.

Table 20. Estimated fire sizes at the time of commencement of firefighting operations and required minimum amounts of forces and resources based on modelling

Fire area class	Area [ha]	Perimeter [m]	The amount of water required to locate the fire [l]	Minimum quantity of fire extinguishing equipment
1	<0.01	<50	<400 (total extinguishing)	Light patrol and firefighting vehicle or handheld equipment
2	0.01-0.05	50-100	400-2500 (total extinguishing)	Medium firefighting vehicle
3	0.05-0.25	100-200	400-2500 (edge extinguishing)	Medium firefighting vehicle
4	0.25-1	200-400	2500-5000 (edge extinguishing)	Two small firefighting vehicles
5	1-3	400-700	5000-10000 (edge extinguishing)	More than two medium firefighting vehicles

The share of tree stand area in the Polish part of the UNESCO ESC depending on the modelled fire area for the five classes mentioned above is presented in Table 21.

Table 21. Share of tree stand area depending on the expected fire area

Fire area class	The share of the stand area depending on the expected fire area calculated for the conditions		
	Litter humidity 12% and wind speed 5m/s	Litter humidity 12% and wind speed 2m/s	Litter humidity 20% and wind speed 2m/s
1	0.0	0.0	7.3
2	11.0	14.2	88.3
3	32.8	79.6	4.4
4	54.4	6.2	0.0
5	1.8	0.0	0.0

For the most unfavourable conditions considered in the analysis, i.e. litter humidity of 12% and wind speed of 5 m/s, the fire area will be larger than 0.05 ha in the entire area of the Forest. In these conditions, the largest area is made up of stands in the case of which the predicted fire area is classified as class 4 (0.25-1 ha), and also where within a small part fires can occur, which at the time of commencement of extinguishing operations will have an area of 1-3 ha. The predicted fire sizes for these meteorological conditions generalized to the level of the division are presented on map 16.

For the litter moisture content of 12% and wind speed of 2 m/s, the fire area will also be larger than 0.05 ha in the entire area of the Forest. However, in these conditions, the largest area is made up of stands, in the case of which the predicted fire area is classified as class 3 (0.05-0.25 ha) and fires larger than 1 ha will not occur. The predicted fire sizes for these meteorological conditions, generalized to the level of the division, are shown on map 17.

For the most favourable conditions, i.e. litter moisture of 20% and wind speed of 2 m/s, the fire area will be smaller than 0.25 ha in the entire area of the Forest. In these conditions, the largest area is made up of stands in the case of which the predicted fire area is classified as class 2 (0.01-0.05 ha). Fires can occur in a small part of the forest, which at the time of commencement of extinguishing operations will have a very small area of <0.01 ha. The predicted fire sizes for these meteorological conditions generalized to the level of the division are shown on map 18.

4. Forest fire extinguishing plan in the Białowieża Forest

4.1. Organization of fire protection. National Rescue and Firefighting System

Fire protection issues are regulated by the *Act of 24 August 1991 on Fire Protection (Journal of Laws of 2019, item 1372, as amended)*, according to the provisions of which fire protection, including in forest areas, consists in the implementation of projects aimed at protecting life, health, property or the environment against fire, natural disaster or other local threat, among others by:

1. preventing the occurrence and spread of forest fires;
2. providing forces and means to combat forest fires;
3. carrying out rescue operations, including in particular fire extinguishing operations.

The basic body in the field of fire protection is the State Fire Service. Additionally, fire protection units are Volunteer Fire Departments, organizational units of the Military Fire Protection or plant fire departments.

In order to create a uniform and coherent system, bringing together various rescue entities related to each other, so that any rescue action could be taken effectively, the State Fire Service organized the National Rescue and Firefighting System, the organization of which is specified in the *Regulation of the Minister of Internal Affairs and Administration of July 3, 2017 on the detailed organization of the national rescue and firefighting system (Journal of Laws of 2017, item 1317, as amended).*

The National Rescue and Firefighting System (pl. Krajowy System Ratowniczo-Gaśniczy - KSRG) is an integral part of the internal security organization of the state, aimed at saving life, health, property or the environment, forecasting, recognizing and combating fires, natural disasters or other local threats. The system brings together fire protection units, other services, inspections, guards, institutions and entities that voluntarily agreed to cooperate in rescue operations under a civil law agreement. The main goal of the KSRG is to ensure the protection of life, health, property or the environment, within the framework of actions taken by the State Fire Service and other rescue entities (with particular emphasis on the Volunteer Fire Service), by:

1. fire extinguishing,
2. elimination of local threats (rescue operations),
3. chemical and ecological rescue,
4. technical rescue,
5. medical rescue in the scope of providing qualified first aid.

The National Rescue and Firefighting System is based on the State Fire Service, the leading rescue service financed from the state budget, as well as on the Volunteer Fire Departments financed from local government budgets and subsidies from the state budget. The partnership of these services is based on mutual cooperation, implementation of the task, organizational, training, equipment and documentation standards expected by the state, with the possibility of organizing rescue and humanitarian aid both within the country and abroad. The Chief Commander of the State Fire Service is the central government

administration body in matters of the organization of the KSRG and fire protection. He or she reports to the minister responsible for internal affairs, who supervises the functioning of the KSRG.

The system operates at three administrative levels corresponding to the country's administrative structure:

1. county-wide (district) – basic executive level, actions are carried out by county (district) forces,
2. provincial – coordination and support of rescue actions when county (district) forces are insufficient,
3. national – coordination and support of rescue actions when province forces are insufficient.

The operational readiness of the KSRG forces and resources, in particular their availability, training and equipment with rescue equipment, enables their urgent allocation according to the protected area criterion, i.e. the necessary forces and resources, which can arrive at the scene of the event in the shortest time possible to eliminate or limit the sudden threat that has arisen. The KSRG structure also assumes that the procedures for implementing basic rescue tasks are adapted to the specific type of incident, including mass events or disasters. Regardless of the network of fire protection units, which are prepared to perform tasks in every field of rescue in the basic scope, the State Fire Service has in its resources dedicated forces and resources to perform specialist rescue activities through highly specialist rescue equipment and appropriate training of the State Fire Service firefighters. Designated forces and resources from across the country are concentrated within the Central Operational Reserve (pl. Centraly Odwód Operacyjny - COO) in:

1. firefighting groups,
2. special groups (evacuation, pumping, flood control with barriers or boats, power supply),
3. logistics subunits,
4. specialist groups,
5. rescue modules for international operations,
6. training groups.

Poland also participates in the EU Civil Protection Mechanism, within which specialist rescue groups (modules) have been reported for international operations, including GFFFV (Ground Forest Fire Fighting using Vehicles) – 6 modules (Kraków, Białystok, Poznań, Olsztyn, Szczecin, Wrocław).

In the event that the forces and resources available to the command post of the State Fire Service, KSRG entities and other entities participating in the rescue operation are insufficient, rescue operations are also carried out by the forces and resources of KSRG entities dispatched from the territory of the province by the relevant provincial commander of the State Fire Service. Whenever the forces and resources of KSRG entities dispatched by the provincial commander of the State Fire Service are not enough, rescue operations are also carried out by KSRG entities dispatched from the territory of the country by the Chief Commander of the State Fire Service.

4.2. Organization of fire extinguishing operations for large-scale forest fires

Organizing firefighting operations in the field of extinguishing forest fires includes planning, organizing and implementing firefighting operations necessary to extinguish a forest fire, as well as to reduce or eliminate the fire hazard. Firefighting operations during forest fires include in particular:

1. recognizing and identifying the threat;
2. securing the firefighting operation zone, including designating and marking the threat zone;
3. eliminating factors likely to reduce the safety of the threatened forest area and the safety of firefighters;
4. priority performance of activities enabling:
   a. reaching people at risk or injured by the forest fire, along with providing them with qualified first aid and evacuation outside the threat zone,
   b. preparing evacuation routes for people at risk or injured and firefighters surrounded by the forest fire,
   c. ensuring the safety of people at risk or injured and firefighters;
5. evacuation and rescue of people, and then animals, and saving the environment and property from the effects of the forest fire;
6. assessing the extent of the fire threat and forecasting its spread;
7. adapting firefighting equipment and vehicles and extinguishing techniques and agents, as well as other rescue means to the type, scale and location of the forest fire;
8. Elimination, limitation or increase of the danger zone;
9. Launching additional rescue forces of KSRG entities.

Firefighting operations during forest fires within the National Rescue and Firefighting System are carried out:

1. forces and resources of KSRG entities adequate to the location of the forest fire;
2. subunits or divisions of operational reserves in the province or central operational reserve.

4.2.1. Reconnaissance

Reconnaissance is an element of the decision-making process by the Rescue Operations Manager (pl. Kierujący Działaniem Ratowniczym - KDR) and includes an assessment of the situation and of possibilities (calculation of forces and resources necessary to quickly, efficiently, effectively and safely extinguish the fire). Reconnaissance is a deliberately organized action continued throughout the rescue operation that leads to obtaining as much information as possible regarding the situation of the event. A well-conducted reconnaissance has a decisive impact on the success of the entire rescue operation. In the forest fire reconnaissance set, four basic groups of information can be distinguished:

1. On the forest fire that has occurred;
2. On the forecasted spread of the forest fire;

3. On rescue forces and rescue support forces;
4. On operational and technical elements of preparing the forest area for fire extinguishing operations during a forest fire.

The scope of information about the forest fire, which is important even before arriving at the forest fire site, should include in particular:

1. identification of the forest district in which the fire started;
2. identification of the forest division in which the fire started (if possible, also provide the forest subdivision for the given forest division);
3. identification of the type of forest fire - subsurface, soil cover, total stand or single tree;
4. identification of the forest area (in ha) burning at the time the fire was reported;
5. identification of the direction of the fire front (for the respective forest divisions);

The scope of information on forecasting the spread of a forest fire, important after arriving at the site of the forest fire, should include the following issues:

1. whether flames or smoke from a forest fire pose a direct threat to people present in facilities (e.g. workplaces, warehouses, public utility buildings, forest parking lots, settlements, observation towers - whether there is a need to evacuate) located in the forests of the forest complex or in its vicinity, or to people travelling on a road or railway line running through a given forest complex (whether there is a need to suspend land transport);
2. wind direction and speed;
3. whether so-called "flying fires" are created, and if so, to what distance they spread, which requires the use of further defence;
4. type of surface adjacent to the fire perimeter line (type of tree stand, age and degree of compaction, etc.) and in what direction it spreads;
5. whether the fire perimeter line will encounter natural obstacles in a given direction of spread that stop or significantly limit the spread of the fire, and if so, of what kind (e.g. river, lake) or artificial obstacles (e.g. road, railway line) and over what length;
6. whether in a given forest complex there are places or objects that are particularly endangered and dangerous (e.g. plants posing a risk of industrial accidents, fuel stations, oil pipelines, gas pipelines, places where hazardous materials are stored);
7. what is the meteorological forecast for the next hour, in particular the wind direction and speed.

In order to determine the scope of information on rescue forces, it is necessary to establish the following issues:

1. number of rescuers and firefighting vehicles from fire protection units at the fire scene;
2. forces from entities other than fire protection units arriving at the fire scene;
3. whether the intensity and nature of the burning requires the allocation of additional rescue forces and other firefighting support forces to the fire scene;
4. forecast of the size of the rescue resources provided as a part of the tactical reserve;

5. amount of water and foam concentrate collected in the tanks of firefighting vehicles at the fire scene;
6. division of the area of operations into combat sections;
7. demand for propellants for firefighting vehicles
8. demand for forest maps of the area covered by the fire, taking into account the current fire situation.

The scope of information on operational and technical elements of preparing the forest area for firefighting operations during a forest fire should include the following issues:

1. location of forest divisions in which fire-fighting water draw-off points or primary water sources for fire-fighting purposes are located (distance from the fire perimeter line);
2. identification of additional water sources located in the vicinity of the fire;
3. identification of methods of supplying water to fire-fighting sections;
4. identification of fire access roads important from the point of view of the fire-fighting operations conducted;
5. provision of fire access roads constituting retreat routes and possible evacuation;
6. methods and forms of fire-fighting operations used in individual fire-fighting sections;
7. identification of the location of the nearest forest air base and its equipment in aircraft;
8. identification of the possibility of conducting reconnaissance using aircraft, as well as fire-fighting operations;
9. location of operational landing sites for aircraft or helicopters near a given forest complex;
10. identification of water sources for firefighting purposes in forests (open water reservoirs or watercourses) from which water can be drawn by firefighting helicopters;
11. location of places where it is possible to create a reception point for rescue forces and means of the operational reserve;
12. location of places where a concentration area for rescue forces will be created in the event of the involvement of rescue forces of the operational reserve in firefighting operations;
13. location of the place where the headquarters of the Rescue Operation Commander is established and works.

4.2.2. Allocation of forces and resources of fire protection units

The effectiveness, efficiency and safe performance of fire extinguishing operations during forest fires in the Białowieża Forest largely depend on the rapid dispatch to the place of fire of an appropriate number of fire extinguishing forces from fire protection units, as well as forces at the disposal of the forest area manager – the State Forests or the Białowieża National Park.

Fire protection units from the Hajnówka district are managed by the Command Post of the District Commander of the State Fire Service in Hajnówka. If there are not enough rescue resources, firefighting teams from neighbouring districts and, if necessary, subunits of the Provincial Operational Reserve are

managed by the Command Post of the Podlaskie Province Commander of the Provincial State Fire Service. The Chief Commander of the State Fire Service is the administrator of the subunits of the Central Operational Reserve and in the event of a request submitted by the Command Post of the Podlaskie Province Commander of the Provincial State Fire Service, rescue resources from other provinces will be managed by the Command Post of the Chief Commander of the State Fire Service.

Ensuring a uniform system for allocation fire protection unit forces for specific incidents, including units of the National Rescue and Firefighting System, determining the minimum level of forces dispatched by the control post of the District Headquarters of the State Fire Service in Hajnówka in the first wave to enable effective rescue operations, the minimum standard of operational security of the area after dispatching the rescue resources and the procedure for launching ad hoc security of protected areas in the Hajnówka district are regulated by the *"Principles for allocation of fire protection unit forces and the principles of ad hoc operational security of the area of the Hajnówka district after dispatching rescue resources".*

An important element which affects the course and effectiveness of any rescue operation is the time of arrival at the incident scene. The fire protection units with headquarters closest to the forest areas are: OSP in Białowieża, JRG in Hajnówka, OSP in Narewka, OSP in Lewków Stary, OSP in Olchówka, OSP in Siemianówka, OSP in Nowokornin, OSP in Mochnaty and OSP in Orzeszków, and these units would be dispatched first to potential incidents, depending on where the fire was detected.

4.3. Forces and resources of the fire protection units of Hajnówka district

The organizational structure of the District Headquarters of the State Fire Service in Hajnówka includes the Rescue and Firefighting Unit in Hajnówka (ul. 11 Listopada 4) and the JRG PSP Station in Czeremcha (ul. Boczna 14). 11 firefighters in total are on duty every day (7 ones in the JRG in Hajnówka, 3 ones in the JRG PSP Station in Czeremcha and 1 officer in the Command Post of the District Commander of the State Fire Service in Hajnówka). Moreover, in the event of long-term incidents, rescuers who are not on duty are called - every day at least 4 firefighters are on so-called home duty and, if necessary, after a telephone call, they immediately head for the unit. The equipment of firefighting vehicles and special units of the State Fire Service in the Hajnówka district is presented in Table 22.

Table 22. Equipment of firefighting vehicles and special units of the State Fire Service in the Hajnówka district

Unit	Type of vehicle	Type
KP PSP in Hajnówka	SLOp	Special-operational
	SLOp	Special-operational
	SLKw	Special-quartermaster
	SLKw	Special-quartermaster
JRG PSP in Hajnówka	GBA 3/30/4,7	Medium fire-fighting
	GBA -Rt 2,5/30	Medium fire-fighting
	GCBA 5/40	Heavy fire-fighting

	GCBA 9,5/64	Heavy fire-fighting
	GCBM 25/16	Fire-fighting - tank
	SHD 23,1	Special – bottle jack
	SLRR	Special – reconnaissance - rescue
JRG PSP post in Czeremcha	GBA 2,5/24	Medium fire-fighting

In the Hajnówka district, there are 35 volunteer fire brigades in total. 24 units are equipped with at least one fire truck, 16 of which are included in the KSRG (table 23). The remaining 11 volunteer fire brigades are classified as type M units, which do not have a truck, but only basic rescue and firefighting equipment (table 24).

Table 23. Equipping Volunteer Fire Department units included in the KSRG in the Hajnówka district with firefighting vehicles

Commune	Organizational unit	Type of vehicle	4x4 or 6x6 drive (YES/NO)
Hajnówka	OSP Mochnate	GBA 2,5/30/4,7	YES
	OSP Nowokornino	GBA 3/30/4,7	YES
Czeremcha	OSP Czeremcha	GCBA 5/24/1,5	YES
		GCBM 15/8	NO
	OSP Czeremcha Wieś	GBA 2,5/30/4,7	YES
Narewka	OSP Narewka	GBA 2,5/30/4,7	YES
		GCBM 10/18	NO
	OSP Siemianówka	GBA 2,5/24/3	YES
	OSP Lewkowo Stare	GBA 2/30/1,3	YES
Białowieża	OSP Białowieża	GBA 2,5/24/1,4	YES
		GCBA 8/50/5	YES
Dubicze Cerkiewne	OSP Dubicze Cerkiewne	GBA 2,5/30/4,7	YES
		GCBA 6/32	NO
	OSP Tofiłowce	GBA 2,5/24/1,5	YES
Kleszczele	OSP Kleszczele	GBA 2,5/30/4,7	YES
		GCBAM 5/32/8	YES
Czyże	OSP Czyże	GBA 2,5/30/4,7	YES
	OSP Klejniki	GBA 2,2/20	YES
Narew	OSP Narew	GBA 2,5/30/4,7	YES
		GCBA 6/32	NO
	OSP Trześcianka	GCBA 3/24	NO
	OSP Łosinka	GBAM 2,5/20/8	NO

Table 24. Equipping the Volunteer Fire Department units outside the KSRG in the Hajnówka district and the Military Fire Service (WSP) with firefighting vehicles

Commune	Name of the unit	Type of Vehicle
Hajnówka	WSP – 2. Regional Logistics Base Depot Hajnówka	GBA 2,5/10
		GBA 2,5/16
	OSP Orzeszkowo	GBA 2,5/16
Dubicze Cerkiewne	OSP Werstok	GBA 2,3/20/1
	OSP Koryciski	GBA 2,5/16/1,2
	OSP Stary Kornin	GBA 2,5/8
Kleszczele	OSP Dobrowoda	GCBA 6/32
	OSP Dasze	GCBA 6/32
Narew	OSP Tyniewicze Duże	GBM 2,5/8
Narewka	OSP Olchówka	GBAM 3/6/8
		GCBA 6/32

Furthermore, in the Hajnówka district there is a military unit – 2. Regional Logistics Base Hajnówka Depot, where the Military Fire Department operates.

In accordance with the agreement concluded with the District Commander of the State Fire Service in Hajnówka, the Military Fire Department can occasionally participate in operations outside the Hajnówka Depot, the access to which does not exceed 16 km. The Military Fire Department is dispatched for rescue operations at the request of the Command Post of the District Commander of the State Fire Service in Hajnówka. The equipment base of the Military Fire Department consists of two medium rescue and firefighting vehicles: GBA 2.5/10 and GBA 2.5/16.

The location of the State Fire Service, Volunteer Fire Department and Military Fire Department units in the Białowieża Forest region and their firefighting vehicle equipment are shown on map 19.

4.4. Forces and resources of fire protection units of the Podlaskie Voivodeship (province)

Whenever the scale of the incident exceeds the capabilities of the fire protection forces and means of the Hajnówka district, the Podlaskie Province Commander of the Provincial State Fire Service will dispatch rescue resources from other districts of the Podlaskie province to support rescue operations (Table 25). In addition, this function can dispatch specialist equipment located in other districts of the Podlaskie province, necessary for organizing rescue operations during large-scale forest fires in the Białowieża Forest (Table 26). The location of the State Fire Service units in the Podlaskie province and their rescue equipment are shown on Map 20.

Table 25. Equipping the State Fire Service units in the Podlaskie Province with fire-fighting vehicles

County (district)	Organizational unit	Type of vehicle	No.	Distance from Hajnówka [km]
augustowski	JRG in Augustów	GBA	2	163
		GCBA	1	
białostocki	JRG no. 1 in Białystok	GBA	1	70
		GCBA	2	
	JRG Post no. 1	GBA	1	65
		GCBA	1	
	JRG no. 2 in Białystok	GBA	1	76
		GCBA	1	
	JRG no. 3 in Białystok	GBA	1	75
		GCBA	1	
	JRG no. 4 in Białystok	GBA	1	70
		GCBA	1	
		GCBM 28/18	1	
	JRG no. 5 in Łapy	GBA	1	70
		GCBA	1	
bialskopodlaski	JRG in Bielsk Podlaski	GBA	2	28
		GCBA	2	
grajewski	JRG in Grajewo	GBA	2	145
		GCBA	1	
hajnowski	JRG in Hajnówka	GBA	2	*Not applicable*
		GCBA	2	
		GCBM 25/16	1	
	JRG in Hajnówka Posterunek	GBA	1	40
kolneński	JRG in Kolno	GBA	2	168

County (district)	Organizational unit	Type of vehicle	No.	Distance from Hajnówka [km]
		GCBA	2	
łomżyński	JRG in Łomża	GBA	3	134
		GCBA	2	
moniecki	JRG in Mońki	GBA	2	109
		GCBA	1	
sejneński	JRG in Sejny	GBA	2	205
		GCBA	1	
siemiatycki	JRG in Siemiatycze	GBA	1	76
		GCBA	3	
sokólski	JRG in Sokółka	GBA	2	99
		GCBA	1	
		GCBM 15/8	1	
	JRG in Sokółka Posterunek Dąbrowa Białostocka	GBA	1	144
		GCBA	1	
suwalski	JRG in Suwałki	GBA	2	202
		GCBA	1	
	JRG Post in Suwałki	GBA	1	209
		GCBA	1	
wysokomazowiecki	JRG in Wysokie Mazowieckie	GBA	2	85
		GCBA	1	
zambrowski	JRG in Zambrów	GBA	2	107
		GCBA	1	
		GCBM 18/16	1	
Total provincial PSP		GBA	35	
		GCBA	28	
		GCBM	4	

Table 26. List of specialist rescue and fire-fighting equipment in the resources of the State Fire Service in the Podlaskie Province

Type of equipment	Parameters	Organizational unit	Qty
Command and Communication Vehicles			
SDł	-	KW PSP Białystok	1
SLDł	-	KM PSP Suwałki	1
Tankers/fire extinguishing vehicles with a water tank with a capacity of more than 10 m^3			
GCBM 28/18	28 m^3	JRG no. 4 in Białystok	1
GCBM 25/16	25 m^3	JRG in Hajnówka	1
GCBM 15/8	15 m^3	JRG in Sokółka	1
GCBM 18/16	18 m^3	JRG in Zambrów	1
GCBM 18/16	18 m^3	OSP Lipsk (augustowski county)	1
GCBM 15/8	15 m^3	OSP Czeremcha (hajnowski county)	1
GCBA 12/64	12 m^3	OSP Drohiczyn (siemiatycki county)	1
GCBA 11/32	11 m^3	OSP Czarkówka Mała (siemiatycki county)	1
GCBA 11/20	11 m^3	OSP Pełch (siemiatycki county)	1
Hose vehicles / containers			
Hose container	W110 - 3000 m	JRG no. 2 in Białystok	1
SW 3000/600	W110 - 3000 m	JRG in Łomża	1
High-capacity pump units			

Type of equipment	Parameters	Organizational unit	Qty
Pump unit	AP 80/8	JRG in Suwałki	1
Pump unit	AP 80/8	JRG in Grajewo	1
Pump unit	AP 80/8	JRG in Siemiatycze	1
Water & foam cannons			
DWP – mobile	4800 l/min	JRG no. 1 in Białystok	1
DWP – mobile	2900 l/min	JRG no. 1 – JRG Post	1
DWP – mobile	4500 l/min	JRG no. 5 in Łapy	1
DWP – mobile	2400 l/min	JRG in Augustów	1
DWP – mobile	4000 l/min	JRG in Bielsk Podlaski	1
DWP - mobile	3800 l/min	JRG in Grajewo	1
DWP - mobile	5000 l/min	JRG in Hajnówka	1
DWP - mobile	3800 l/min	JRG in Hajnówka	1
DWP – mobile	3600 l/min	JRG in Kolno	1
DWP - mobile	2400 l/min	JRG in Kolno	1
DWP – mobile	4800 l/min	JRG in Łomża	2
DWP – mobile	3200 l/min	JRG in Mońki	1
DWP – mobile	2400 l/min	JRG in Siemiatycze	1
DWP – mobile	5100 l/min	JRG in Sokółka	1
DWP – mobile	2400 l/min	JRG in Sokółka	1
DWP – mobile	4000 l/min	JRG in Zambrów	1
Water tanks			
Z13000	13 m^3	JRG no. 1 in Białystok	2
Z13000	13 m^3	OSP Rozedranka Stara (sokólski county)	1
Z5000 (pneumatic)	5 m^3	JRG no. 4 in Białystok	1
Z5000	5 m^3	JRG in Łomża	1
Z4000	4 m^3	OSP Stary Laskowiec (zambrowski county)	1

4.5. Organization of the Provincial Operational Reserve of the National Rescue and Firefighting System in the Podlaskie Province

In the Podlaskie Province, the Provincial Operational Reserve of the National Rescue and Firefighting System was organized, within which the Podlaskie Reserve Brigade was created, the tasks of which, within the scope resulting from the possessed equipment and training, include eliminating the effects of events that exceed the capabilities of rescue entities from the district, including, among others, fighting large and very large fires.

The subunit whose intended function is to extinguish, among others, large-scale forest areas is the "Białystok" Firefighting Group, which, apart from the command, consists of 21 teams with 74 rescuers. The group can be dispatched in whole or in part, according to the needs of the rescue operations, specified by the person in charge of the rescue operation. This subunit is equipped and supplied in such a way as to provide it with the possibility of conducting long-term rescue operations.

The "BIAŁYSTOK" Firefighting Group consists of standardized rescue and firefighting platoons (table 27), among which the following types can be distinguished:

- “A” type platoon - a platoon of medium firefighting vehicles;
- “B” type platoon " - a platoon of heavy firefighting vehicles;
- “C” type platoon - a support platoon consisting of a water supply section and a section with a supply of foaming agent;
- „D” type platoon - a platoon of heavy firefighting vehicles with water-foam cannons (DWP);
- „E” type platoon - a technical platoon.

Moreover, the "BIAŁYSTOK" logistics platoon was created. It consists of standardized logistics sections (table 28), including the following types:

- material and technical section, the composition and equipment of which enables the implementation of tasks in the scope of supplying tactical subunits with propellants and other necessary consumables and extinguishing agents, neutralizers and other materials and substances necessary for conducting operations, as well as repairing failures of equipment used in operations.
- camp section, the composition and equipment of which enables the organization of an overnight base for rescuers,
- food section, the composition and equipment of which enables the organization of the supply and distribution of meals in quantities adequate to the size of the unit or tactical subunit.

Table 27. List of forces and resources of the "BIAŁYSTOK" Firefighting Group.

Platoon	Organizational unit	Type of vehicle	Maximum forming time
A	GCBA-Rt 5/32	JRG no. 3 in Białystok	140 min
	GBA 2,5/27	JRG in Wysokie Maz.	
	GCBA 5/35	JRG in Sokółka	
A1	GCBA-Rt 5/32	JRG in Łomża	140 min
	GBA 2,5/16/1,8	JRG in Kolno	
	GBA 2,9/16	JRG in Zambrów	
B	GCBA-Rt 5/32	JRG nr 4 in Białystok	140 min
	GCBA 8/50	JRG in Łomża	
	GCBA 8/60	JRG w Mońkach	
C(SW)	GCBA 8/50	JRG in Suwałki	240 min
	AP 80/8		
	GCBA 10/64	JRG in Siemiatycze	
	AP 80/8		
	GCBM 28/18	JRG no. 4 in Białystok	
	Container trailer + SCKn from 1 ext. E platoon	JRG no. 2 in Białystok	
	Hose container 3000/400	JRG no. 2 in Białystok	
	SLKw	KM PSP in Białystok	
	Floating motor pump	JRG no. 1 in Białystok	
C(SSP)	SCKw	JRG no. 2 in Białystok	120 min
	SCKw	JRG in Łomża	
D	GCBA 8/50	JRG no. 1 in Białymstok	120 min
	DWP 4800 l/min.		
	GCBA 8/50	JRG in Bielsk Podlaski	
	DWP 4000 l/min.		
	GCBA 8/50	JRG in Grajewo	
	DWP 3800 l/min		
E	GBA 2,5/16	JRG in Augustów	200 min
	GBA 3/30	JRG in Hajnówka	
	SCKn	JRG no. 2 in Białystok	
	Engineering & technical container	JRG no. 4 in Białystok	

Table 28. List of forces and resources of the Logistics Platoon "BIAŁYSTOK"

Section	Organizational unit	Type of vehicle	Maximum forming time
Firefighting staff and equipment supplying vehicle	KW PSP in Białystok	SLKw	180 min
Camp section	KM PSP in Suwałki	SCKw	
	JRG no. 4 in Białystok	SCKn	
	JRG no. 4 in Białystok	Accommodation container	
	JRG no. 2 in Białystok	SCKn	
	JRG no. 2 in Białystok	Sanitary container	
Food section	KP PSP in Sokółka	SLKw	190 min
	KP PSP in Hajnówka	SLKw	

Within the framework of Provincial Operational Reserve of the KSRG, 15 fire-fighting platoons have also been created, out of which two in the Białystok district and one in the other districts. The platoons consist of 3 rescue and fire-fighting teams of the OSP KSRG and a commander from the State Fire Service. The OSP vehicles included in the WOO platoons have the staff of at least 5 people. If a need to support fire-fighting operations in the Białowieża Forest arises, it is possible to dispatch WOO fire-fighting platoons through the Podlaskie Province Commander of the Provincial State Fire Service, first of all from the districts neighbouring the Hajnówka district, i.e. Białystok district, Bielsk district and Siemiatycze district. The list of forces and resources of those platoons is presented in Table 29. The dispatching of OSP units for the purpose of forming WOO platoons is carried out by the control post of the district (municipal) commander of the PSP from the district in which the dispatched OSPs operate.

Table 29. WOO List of forces and resources of the WOO Firefighting Platoons

Firefighting platoom	Organizational unit	Type of vehicle	Ime needed to get to Hajnówka
Białystok Firefighting Platoon	KM PSP in Białystok	SLRR	120 min
	OSP KSRG Michałowo	GCBA 7/24	
	OSP KSRG Zabłudów	GCBA-Rt 4/30	
	OSP KSRG Supraśl	GCBA-Rt 5/32	
Białystok 2 Firefighting Platoon	KM PSP in Białystok	SLRR	120 min
	OSP KSRG Czarna Białostocka	GCBA 5/32/2	
	OSP KSRG Uhowo	GCBA-Rt 5/24/8	
	OSP KSRG Choroszcz	GCBA 8/50/3	
Bielsk Podlaski Firefighting Platoon	KP PSP in Bielsk Podlaski	SLRR	60 min
	OSP KSRG Orla	GBA 2,5/16	
	OSP KSRG Pasynki	GBA 2,5/16	
	OSP KSRG Piliki	GBA 2,5/16	
Siemiatycze Firefighting Platoon	KP PSP in Siemiatycze	SLRR	120 min
	OSP KSRG Drohiczyn	GCBA 12/64/0,7	
	OSP KSRG Mielnik	GBA 2,5/26	
	OSP KSRG Stadniki	GCBA 5/35/4	

4.6. Organization of the Central Operational Reserve of the National Rescue and Firefighting System in Poland

In order to carry out tasks during rescue operations during fires, natural disasters or to eliminate local threats in a situation where their scope exceeds the capabilities of the National Rescue and Firefighting System forces from a district or province, the Central Operational Reserve (COO) of the National Rescue and Firefighting System has been established. The person authorized to dispatch the COO units and subunits is the Chief Commandant of the State Fire Service, the COO commander or a person authorized by the Chief Commandant of the State Fire Service. The COO units and subunits constitute the forces of the relevant State Fire Service commanders until they are dispatched by an authorized person and can be managed by the relevant State Fire Service commanders, the commanders

of the provincial operational reserve or persons authorized by the relevant State Fire Service commanders within their own area of operation.

The size of the available forces depends on the needs reported by the Rescue Operations Manager, so the COO subunits may be allocated in part or in full, but their dispatched part cannot be smaller than a platoon. When calculating the size of the COO forces necessary for use during rescue operations, the forecasted situation should be taken into account for the time taking into account the alarming operations and the movement of the subunits to the action area.

In the provinces bordering the Podlaskie province, i.e. Lublin and Warmian-Masurian provinces, one COO fire extinguishing group was established, while in the Mazovian province, 2 COO fire extinguishing groups were created.

Should a request for forces and resources be submitted within the central operational reserve, it is expected that a firefighting group from the Lublin province will arrive via the national road DK 19 through Siemiatycze and further towards Hajnówka, firefighting groups from the Mazovian province will arrive via the national road DK 8 through Zambrów and further towards Hajnówka, and a firefighting group from the Warmian-Masurian province will arrive via the national road DK 65 through Grajewo and further towards Hajnówka.

4.7. Performance of fire extinguishing operations

4.7.1. Potential Points of Acceptance of Forces and Resources (PPSiŚ)

A Forces and Resources Acceptance Point is created only upon the order of the Commander-in-Chief or Staff, when, due to the nature and size of the incident, it is necessary to record and coordinate the rescue teams arriving at the scene.

Its responsibilities include:

- receiving arriving forces and resources and providing them with information on orders received from the KDR Staff,
- recording the arrival and departure of forces and resources to and from the PPSiŚ,
- providing ongoing information on arriving forces and resources to the PPSiŚ,
- maintaining communication with the KDR (KDR Staff), the KW PSP command post and the relevant local KM/KP PSP command post,
- directing individual rescue teams to specified and designated combat sections, in accordance with the KDR orders
- keeping records of the complementation of subunits arriving at the scene of the incident,
- providing pilotage for rescue teams to designated combat sections.

For the purposes of carrying out rescue operations when extinguishing forest fires in the Białowieża Forest, for which significant resources of fire protection units will be allocated, potential points of acceptance of forces and resources have been designated. Rescue equipment will be

concentrated in specific locations and it will then be distributed to designated places for the purposes of performing fire extinguishing operations, depending on the needs of the Rescue Operation Manager.

Designated locations where Points of Acceptance of Forces and Resources will be organized (PPSiŚ)

1. Headquarters of the Hajnówka Forest District Inspectorate 23,6073; 52,7361
2. Topiło 23,6228; 52,6369
3. Dubicze Cerkiewne – petrol station parking lot 23.4421; 52.6488
4. Czerlonka 23,7170; 52,6904
5. Headquarters of the Browsk Forest District Inspectorate 23,8004; 52,8273
6. Stare Masiewo 23,9239; 528171

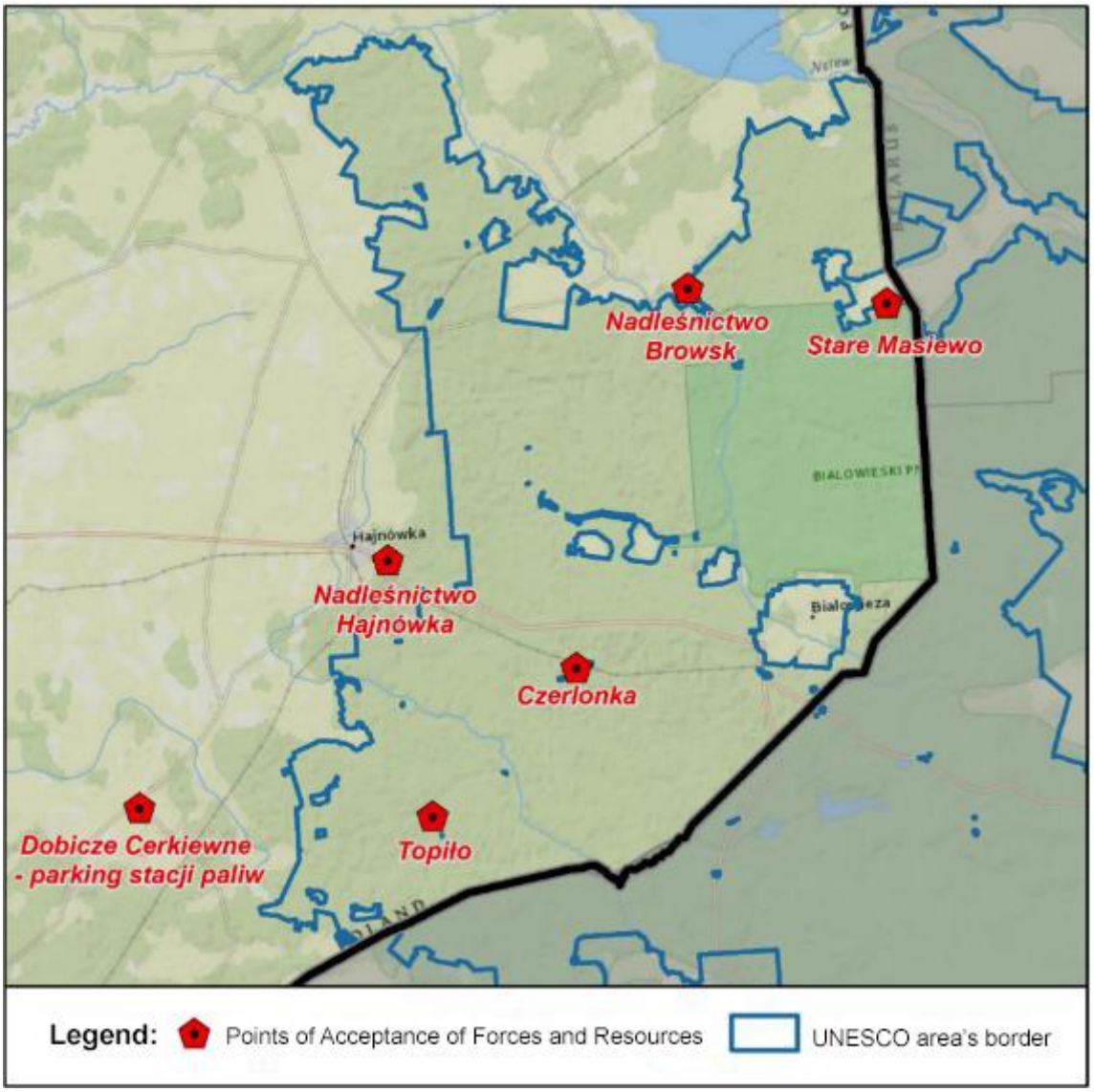


Figure 12. Deployment of important specialized equipment in the Podlaskie province

4.7.2. Possibility of using aircraft for rescue operations

Firefighting operations carried out by fire protection units can be supported by firefighting aircraft (planes and helicopters) held by the State Forests. The aircraft are parked at the Forest Air Bases located on the territory of the individual Regional Directorates of the State Forests. The undoubted advantage of aircraft and helicopters is the ability to reach everywhere where there is no access for ground equipment or where there is a direct threat to rescuers. The basic extinguishing agent is water dropped in the form of a bomb or a trail.

In the area of operation of the Regional Directorate of the State Forests in Białystok there are two Forest Air Bases - in Białystok (Krywlany airport) and in the town of Rostki (in the Warmian-Masurian province) (Figure 13). In each base there is 1 patrol and firefighting aircraft. In addition, based on an agreement concluded by the Regional Directorate of the State Forests in Białystok, it is possible to use the airport which is privately owned by the company "Pronar", in the town of Narew in the Hajnówka district for operational activities using patrol and firefighting aircraft.

In the area of the neighbouring Regional Directorates of the State Forests, the RDLP in Lublin has two firefighting aircraft at its disposal at the base in Mielec, the RDLP Olsztyn - two firefighting aircraft in Szymany, while the RDLP Warsaw has access to a firefighting aircraft at the Babice base.

Operational capabilities of the M 18B Dromader aircraft in the event of a fire in the Białowieża Forest using the Narew airport for water replenishment.

(A)

1. Take-off from Białystok: 700 liters of avgas fuel and 1,800 liters of water. The flight to the farthest spots in the Polish part of the Białowieża Forest (e.g. the Białowieża region), locating and extinguishing the fire, and arriving and landing at the airport in Narew takes about 40 minutes.
2. Take-off: Narew (1900 of water) landing: Narew about 30 minutes.
3. Take-off: Narew (2000 of water) landing: Narew about 30 minutes.
4. Take-off: Narew (2000 of water) landing: Narew about 30 minutes.
5. Take-off: Narew (2000 of water) landing: Białystok about 40 minutes.

**refueling approximately once in every 20 minutes.*

(B)

1. Take-off from Rostek: 700 liters of avgas fuel and 1,800 liters of water. The flight of the aircraft to the furthest spots in the Polish part of the Białowieża Forest (e.g. the Białowieża region), locating and extinguishing the fire, and the arriving and landing at the airport in Narew takes about 1 hour and 15 minutes.
2. Take-off: Narew (1900 of water) landing: Narew about 30 minutes.
3. Take-off: Narew (2000 of water) landing: Narew about 30 minutes.
4. Take-off: Narew (2000 of water) landing: Narew about 30 minutes.
5. Take-off: Narew (2000 of water) landing: Białystok about 40 minutes.

** refueling approximately once in every 20 minutes.*

Flight time depends on distance and wind force and direction. When using the airport in Narew for operational activities, water replenishment in aircraft is carried out by the Narew Volunteer Fire Department. It is also possible to organize refueling at the airport in Narew.

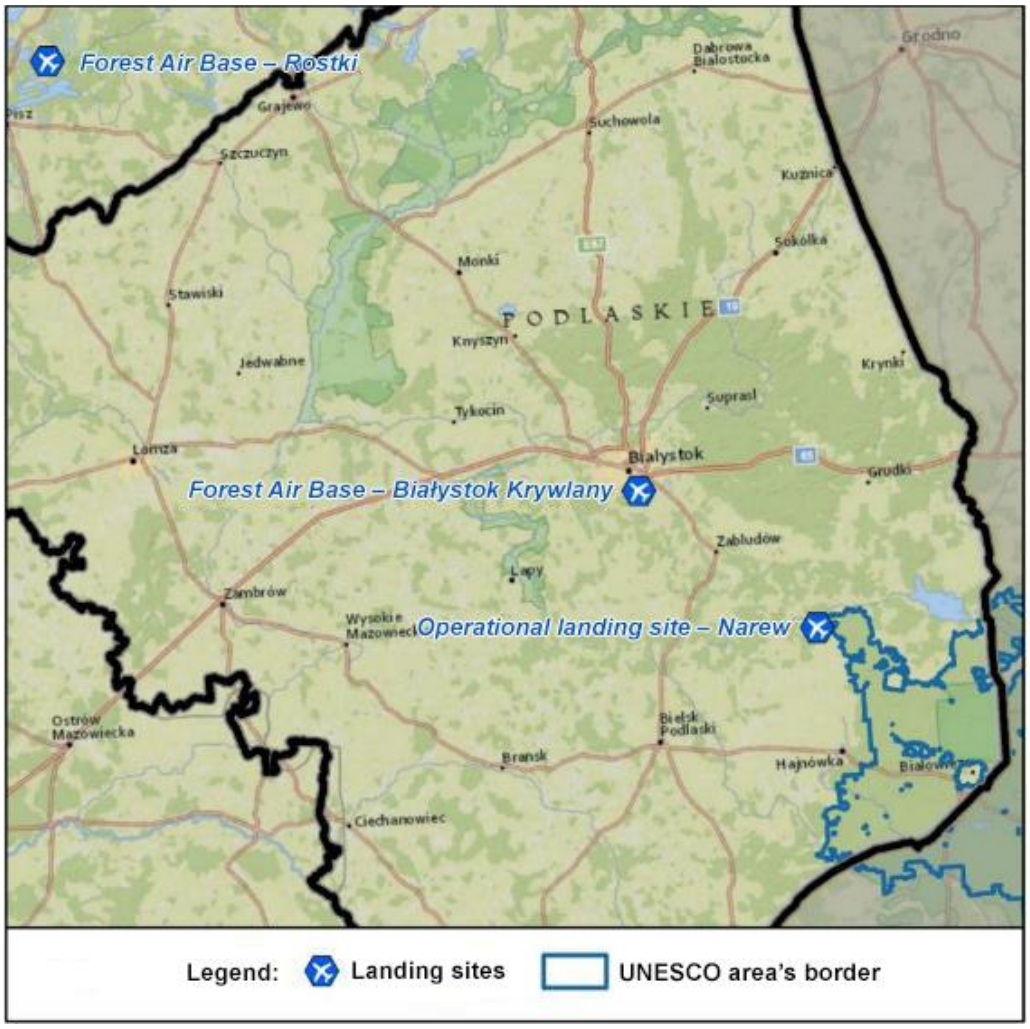


Figure 13. Location of the Forest Air Bases and operational landing site in Narew

Should a fire break out in the Białowieża Forest, the Emergency and Dispatch Point of the Regional Directorate of the State Forests in Białystok, in the first phase, dispatches a firefighting aircraft from the Forest Air Base in Krywlany and verifies the availability and possibility of launching other aircraft held by the State Forests.

In addition, it is possible to use unmanned aerial vehicles controlled remotely from the ground by radio, which make part of the equipment of the State Fire Service, Border Guard or Police. Such platforms (drones) - an unmanned aircraft or e.g. a quadrocopter, can patrol a specified area using visible light or thermal imaging cameras and send photos or images online as well as record photos and videos on their own data carrier for playback after the mission is completed. It is also possible to identify important places using geographical coordinates (GPS). The use of this type of equipment for the purposes of locating the source of the threat and assessing the place of the incident is particularly important in the case of and dangerous areas with difficult access. For safety reasons, the movement of unmanned aerial vehicles cannot take place in the zone of firefighting flights.

4.7.3. Organization of the rescue operations staff

The Rescue Operations Manager decides on the designation and organization of a rescue operations staff, whose tasks include developing the concept of organizing a rescue operation for the needs of the KDR. The staff is managed by the chief of staff, who organizes its work. In addition to State Fire Service officers, the staff should include representatives of the State Forests, Białowieża National Park, Police, Border Guard, representatives of medical services, crisis management, individual inspections, experts, etc. The most convenient place for the staff to work is a building with telecommunications and ICT infrastructure, in particular a PSP or OSP facility, but it is possible to place the staff in field conditions in a container, a special staff vehicle or in one or more tents. After the staff is established, the KDR holds a meeting with its members, at which he or she presents the main goal to be achieved and assigns tasks to be implemented, which should be clearly and precisely defined. The basic actions resulting in the success of an organized fire extinguishing operation include:

1. appropriate selection and designation of the action headquarters (rescue operations management location), known to all participants of the action, appropriately marked (in the location itself and on access roads), selected so that no change is necessary, even in the case of operations lasting several days;
2. establishment of the action headquarters (in full or partial development - depending on the scale of the incident), which should perform the following tasks:
   a. draw the fire situation and the course of action on a topographic map and maps, which must be previously made in the number of copies necessary for the commanders of combat sectors and cooperating services and institutions;

b. indicate the points of acceptance of forces and resources on access roads, in a place that guarantees free access and passage of vehicles, with constant communication with the headquarters and sanitary facilities;
c. organize command and cooperation communication;
d. organize drinks, and then food and basic sanitary conditions for direct participants in the action and reserves;
e. provide medical assistance;
f. in the area of the fire, stop the movement of people and services not participating in the action;

3. dividing the fire area into combat sections, the number and length of which should depend on the size of the incident, provided that the length of one combat section should not exceed the length of 2–4 forest divisions, while the boundaries of the combat sections should run along characteristic points, e.g. along the boundaries of spatial divisions or natural elements such as a road, railway line, power line, watercourse;
4. appointing commanders of combat sections and assigning them guides on behalf of the forest manager;
5. appointing representatives of cooperating services to the staff, in particular commanders (supervisors), who have the authority to issue orders and enforce them onto officers (employees) subordinate to them within their own organizational structures; assigning representatives of individual services to cooperate with commanders of combat sections, including in particular representatives of forest services, commanders of military subunits (units), Police, Border Guard and other services, inspections;
6. appointing an air force coordinator in the staff responsible for the full and safe implementation of all aerial operations and cooperation with ground forces.

The staff should first of all establish variants of actions aimed at localizing the fire on its front and determine the types of tactical actions on the flanks and rear of the fire. The implementation of these procedures is a necessary minimum for further application of appropriate extinguishing technologies and tactics oriented to further success in extinguishing operations.

Variants of firefighting actions during forest fires include:

1. frontal fire extinguishing [from the front of the fire];
2. flanking fire extinguishing [from the sides (flanks) of the fire];
3. extinguishing from the rear of the fire;
4. surrounding fire extinguishing (the entire line of fire spreads).

Forest fire extinguishing methods include:

1. suppressing the fire with a suppressor or branches by knocking down the flames while simultaneously sweeping burning materials into the center of the fire (during soil cover fires as a supplementary method);

2. suppressing the fire - backfilling the burning zone of the forest floor cover and directly in front of the fire perimeter line with soil (mineral soil, but not peat) (during soil cover fires as a supplementary method);
3. ploughing a barrier strip (so-called fire break) by mineralizing the soil as close as possible to the fire perimeter line; the ploughed strip should be an additional communication route for firefighting teams (during soil cover fires, shallow muck fires and for securing fire remnants);
4. Burning, i.e. controlled burning of a strip of soil cover, mainly at the fire front and after localization on the entire fire perimeter in order to straighten the line of the fire (during large fires of soil cover and total tree stand fire);
5. Water extinguishing should be used in attack or defense, mainly in the form of droplet (sprayed or misty) extinguishing jets; compact extinguishing jets should be used only when it is necessary to supply water at a longer distance to places of intensive burning (during any type of forest fire and to secure fire remnants);
6. Extinguishing with foaming and softening agents (surfactants).

4.7.4. Cooperation with the State Forests and the Białowieża National Park during rescue operations related to extinguishing forest fires

All employees of the State Forests and the Białowieża National Park are obliged to take action using available methods and means to limit the spread of fire. Until the arrival of the fire brigade unit at the site of the fire, the head of the unit, his or her representative or the most senior employee leads the extinguishing action and performs other activities necessary to develop further stages of the rescue action during the extinguishing of forest fires. After the arrival of the fire brigade unit, he or she provides the arriving commander (directing the rescue action) with all information he or she has on the current situation, location in the area and previous activities. The representative then undertakes advisory tasks in the field of forestry and coordinates the implementation of tasks performed by the forces and resources of the State Forests and BPN.

The basic task related to the rescue operation conducted while extinguishing forest fires is to mobilize one's own forces and resources and then act as the host at the site of the operation. The specific tasks and responsibilities of the respective forest district include:

1. creating the necessary structure for organizing and directing rescue operations, and especially for operations in the following hours (days);
2. designating the place of directing own forces and resources;
3. allocating the forest district forces and resources for action and monitoring their arrival;
4. monitoring the forest fire threat and forecasting the possibility of fire spread;
5. coordinating the participation of forces sent from other units;
6. providing cartographic materials for the organization of activities;
7. ensuring logistics for own forces and resources;

8. organizing and providing drinks and meals for forestry inspectorate employees,
9. documenting all important information and decisions made in the PAD and on the site of the action;
10. performing other tasks at the request of the KDR or action staff;
11. marking the fire situation and the location of own forces and resources on an economic map on a scale of 1:10,000 for fires larger than 10 ha;
12. appointing a guide from the forestry inspectorate or BPN for each commander of the established combat section;
13. establishing access roads with the KDR and marking them with boards or in another way;
14. organizing communication for the control of LP and BPN forces and cooperation with other participants in the action;
15. appointing an air force coordinator responsible for the safe implementation of all aerial activities and cooperation with ground forces;
16. planning with the KDR the date of taking over the fire site and determining the methods of extinguishing it and supervising it, ensuring the necessary forces and resources.

4.7.5. Cooperation with the Police during rescue operations related to extinguishing forest fires

As part of cooperation during the implementation of activities related to the organization of fire extinguishing operations in the Białowieża Forest area, Police units will carry out the following undertakings:

1. ensuring public safety and order in the area of the operations, including designating detours;
2. alienating the threatened area;
3. cooperating and exchanging information with public administration bodies and other institutions competent to fight against fires, which are part of the National Rescue and Firefighting System;
4. obtaining information about the location and scale of the incident;
5. clearing evacuation routes to ensure collision-free passage for rescue services, directing traffic in the area of the incident, clearing critical intersections;
6. providing assistance in the evacuation of people and property;
7. securing property left behind by evacuees;
8. carrying out procedural tasks related to the incident (including: determining the details of victims, injured parties, perpetrators, witnesses).

The scope of detailed tasks of the Police at the stage of implementation of activities includes:

1. determining the scope of cooperation with the State Fire Service, as the leading service at the scene of the incident,
2. alienating the area of the threat in consultation with the Head of the Rescue Operations on behalf of the State Fire Service and informing the population about the existing threat,
3. helping during the evacuation of injured or endangered persons,
4. ensuring the patency of access roads for rescue entities participating in the operations,
5. directing traffic, stopping vehicular traffic, organizing detours of endangered areas and informing about them,
6. guiding rescue units and securing passages during rescue operations related to extinguishing forest fires,
7. Enforcement of compliance with the regulations and orders of the Rescue Operations Manager,
8. Informing the population about the threat, directions and distances and the method of access or arrival to evacuation assembly points,
9. Ensuring public safety and order, including: in the area of rescue services, workplaces of medical points, collection points for the injured people, in places of distribution of humanitarian aid,
10. Protection of abandoned property,
11. Preparation and securing of own facilities and equipment in the event of a threat caused by fire,
12. if necessary, preparing the existing logistic equipment that could be additionally used for providing assistance by delivering to the Police among others: power generators, tents, thermoses, blankets, sleeping bags and additional means of transport,
13. sending an operational and procedural group to the area of the incident,
14. conducting press and information activities within the scope of the activities carried out,
15. participating in the work of the action headquarters.

The organizational unit of the Police in the Hajnówka district is the District Police Headquarters in Hajnówka, within the structures of which operate Police Stations in Białowieża, Narewka and Czeremcha.

4.7.6. Cooperation with the Border Guard during rescue operations related to extinguishing forest fires

As the Białowieża Forest is located within an area covering the territory of two countries, the Border Guard is also an important entity cooperating with the State Fire Service as the coordinator of activities. While cooperating during the implementation of activities related to the organization of fire extinguishing operations in the Białowieża Forest, Border Guard units will carry out the following activities:

1. enabling efficient crossing of the state border during rescue operations in the event of cross-border incidents;
2. ensuring safety in international communication and public order at border crossings, and, within the competence of the Border Guard, also in the border zone;
3. conducting activities to ensure efficient access and maneuvering of vehicles participating in rescue operations;
4. directing traffic and issuing instructions regarding the use of roads in the border zone;
5. order and protection activities during rescue operations;
6. limiting access for unauthorized persons;
7. assistance in evacuating people and property;
8. securing the property of evacuated people at storage points in cooperation with the Police, among others by organizing patrols to prevent theft;
9. directing traffic, stopping vehicular traffic and providing detours;
10. piloting rescue units and securing passages during rescue operations related to extinguishing forest fires (especially in border areas);
11. participation of a helicopter in rescue operations;
12. enabling the movement of specialist equipment of the State Fire Service and patrolling areas using a helicopter and a patrol plane;
13. participation in the work of the action staff.

4.7.7. Principles of organizing cooperation communications in the area of rescue operations related to extinguishing forest fires

The organizer of communication in the relationship between the place of operations – PSP Control Centre – Staff is the Rescue Operations Manager.

Three rescue operation management levels can be distinguished:

1. intervention – carried out in a danger zone or rescue operation zone in order to perform rescue operations and ensure the safety of rescuers; intervention management covers forces no larger than one group,
2. tactical – carried out on the border of the danger zone or beyond it in order to implement adopted tactics or a specific strategy and supervise intervention management; tactical management covers forces no larger than one battalion or forces consisting of specialist rescue groups;
3. strategic – carried out in order to determine and adopt the necessary strategy to eliminate the threat and supervise tactical management; strategic management covers operational reserve forces in the area of the province, central operational reserve forces or forces larger than one battalion.

Within the National Rescue and Firefighting System, communication is organized on the basis of the *Methodology of conduct during the organization of communication for the needs of the Rescue Operation Commander*.

Furthermore, in order to ensure the proper organization of communications in the area of operations, it is possible to use the command and communication vehicles of the Fire Department, which are part of the equipment of the State Fire Service in Białystok and the State Fire Service in Suwałki.

The equipment of the Fire Department and the installed integrated ICT systems ensure the transfer of all communication functions from brick and mortar centers.

The vehicle structure is divided into the following parts:

- a staff compartment with a table and a workspace for four people, which guarantees comfortable work in all weather conditions;
- an operator compartment with two computer stations integrating all the vehicle's ICT systems with access from the staff compartment.

Use of the radio network of cooperation of the Ministry of Internal Affairs services during rescue operations (channel B112)

Should a need arise to ensure direct exchange of information between officers (persons) of various services of the Ministry of Internal Affairs directly involved in the operations, after the decision of the commander of the operation at the site of the jointly conducted operations:

1. The KDR exchanges information with the commanders of specific services on channel B112, and he or she communicates with subordinate rescuers on the command channel or the rescue and firefighting channel.

2. Whenever there is a need for direct exchange of information between PSP rescuers and officers of other services, the KDR instructs the subordinate rescuers to switch to channel B112, where he or she maintains communication with them.

In addition to the services subordinate to the Ministry of Internal Affairs, the State Forests were also included in the group of users of the B112 channel in 2015. Each Forest District is equipped with radiotelephones enabling operation on the B112 channel.

Radio retransmission network - RSR (channel BF171)

Whenever it becomes necessary to ensure communication during rescue operations in a large area or in an area with poor radio wave propagation conditions (forest areas, etc.), it is recommended to launch the Radio Retransmission Network (RSR) based on a mobile radio repeater, as far as technical capabilities allow. The Radio Retransmission Network can be used as:

a) an additional channel in the rescue and firefighting network;

b) an additional channel in the command and cooperation network.

The consent to launch the RSR is issued by SK KW at the request of the KDR.

4.7.8. Logistical support for rescue operations

Long-term rescue operations, as a result of extinguishing a large-scale forest fire, require cooperation with local government and provincial administration, other services such as the army, police, state forest administration, health centers, schools and the local population. Undoubtedly, during such an event, crisis management structures will be activated at the level of specific communes or even at the level of the starosty (county head). When organizing logistic support for rescue operations, the following issues should be taken into account:

1. exchange of rescuers:
   - ensuring a system of replacements and coordinating the transport of rescuers together with their personal and special equipment to the place of firefighting operations;

2. ensuring food and beverages:
   - organization of food and beverages for fire protection units,
   - organization of food and beverages for cooperating entities,
   - coordination of the delivery of food and beverages to the meeting point or site of firefighting operations,
   - recognition of the possibilities of organizing collective catering based on catering points;

3. extinguishing agents:
   - organizing and ensuring water supply, water drawing stations located at significant distances from the fire site,
   - ensuring continuity of supplies of chemical extinguishing agents;
4. accommodation:
   - organization and provision of accommodation for fire protection units based on facilities of entities adapted to accommodate people,
   - organization and provision of accommodation for fire protection units based on a camp constructed using accommodation and sanitary equipment,
   - determination of needs in terms of transport, evacuated people and property,
   - preliminary calculation of living needs for evacuated people and animals,
   - provision of a workplace for the staff directing the Rescue Operation;
5. propellants:
   - providing fuels and lubricants for motor equipment used during fire-fighting operations;
6. medical protection:
   - organization and securing of efficient operation of emergency medical assistance points for the needs of fire protection units.
   - providing medical assistance to injured persons;
7. Equipment reserves; replacement, repairs:
   - meeting the demand for specialist equipment, materials and devices necessary for the activities,
   - providing specialist equipment and vehicles,
   - securing spare parts, emergency repair locations,
   - identifying entities performing equipment repairs,
   - ensuring replacement of damaged equipment,
   - organizing equipment stock (communication equipment, lighting, respiratory protection devices, clothing, etc.);
8. ordering and protection functions:
   - securing the scene of the incident,
   - organizing points for receiving forces and resources,
   - organizing storage places for evacuated property and protecting these places.

4.7.9 Principles for the exchange of information in the event of a cross-border threat

The exchange of information between Poland and Belarus on potential and actual threats resulting from a possible fire in the Białowieża Forest which is likely to spread to the territory of the neighbouring country will be carried out through contact points organized at the central and provincial levels. At the central level, the exchange of information will be carried out between the National Rescue Coordination and Population Protection Centre of the Main Headquarters of the State Fire Service in Warsaw and the Republican Centre for Management and Response to Emergency Situations of the Ministry for Emergency Situations of the Republic of Belarus in Minsk.

At the level of the Podlaskie Province, the exchange of information will be carried out between the Province Crisis Management Centre of the Podlaskie Province Office in Białystok and the Grodno Regional Centre for Management and Response to Emergency Situations of the Office of the Ministry for Emergency Situations of the Republic of Belarus in Grodno, as well as the Brest Regional Centre for Management and Response to Emergency Situations of the Office of the Ministry for Emergency Situations of the Republic of Belarus in Brest.

5. Recommendations for fire protection and fire extinguishing in the Białowieża Forest

The analysis of the current fire hazard in the Białowieża Forest, taking into account changes in its area primarily due to the dieback of spruce following the bark beetle outbreak, showed an increase in potential risk, especially in 2016-2018. This increase was caused by an unprecedented large accumulation of flammable biomass in the form of dead wood, especially dead small wood in the initial stage of decomposition and the appearance of grass cover due to thinning of stands. It favors the possibility of formation and rapid spread of a fire, especially in exposed places, with grass fields and dead small wood in the initial stages of decomposition. The area with high potential flammability in 2019 accounted for 11.3% (flammability class A), with medium flammability 39.6% (flammability class B) and 49.1% with low flammability (flammability class C) of the total area of the Forest. In 2022, based on the valuation data of the Office of Forest Management and Geodesy in Białystok collected as a part of the development of new forest management plans for the Forest districts, the flammability classes of tree stands were re-established. Stands representative of class A accounted for 11.3%, class B - 37.3% and class C - 51.4% of the Forest area. In 2000-2024, 138 fires occurred in the Białowieża Forest on an area of 52.2 ha. In the period since the outbreak (2012–2024), the number of fires was 69, covering an area of 16.37 ha.

The fire load, which is the basic criterion for assessing the potential fire risk, increased almost sevenfold compared to 2011 (15.8 t/ha), reaching an average maximum value of 109 t/ha in 2017. In some separated areas in the Białowieża Forest District, it even reached 295 t/ha. The limit above which extinguishing the fire often becomes impossible is the fire load exceeding 10 t/ha (Castellnou and Hernandez 2018). The accumulation of flammable material in the form of lying dead wood makes rescue operations difficult and blocks access to some places, which may consequently lead to an increase in the

area covered by fire. Since 2020, the rate of tree stand decay has significantly decreased, and the decomposition of dead wood and the natural regeneration which started in overexposed places have reduced the fire risk, although in places where there are exposed surfaces covered with grass, raspberries or ferns, this risk will occur before the start of the vegetation phase or during periods of long droughts. It is estimated that around 2029, the fire risk in the Forest may return to the levels existing before the bark beetle outbreak, unless other unforeseen disturbances occur. The purpose of the developed *"Firefighting Plan for the Protection and Extinguishing of Forest Fires for the Polish Part of the Białowieża Forest Transboundary World Heritage Site"* is to contribute to the protection of the one-of-a-kind nature of the Białowieża Forest. In order to accomplish it, apart from actions aimed at minimizing the fire hazard and the risk of a fire, it is crucial to make the Forest area available to rescue forces and provide water for extinguishing purposes. Rapid detection of fire and alarming activity, as well as initiating rescue actions at the earliest possible stage of fire development, have a significant impact on the amount of direct and indirect losses provoked by each fire. At the stage of development of the Plan, the applicable national regulations on fire protection were taken into account which basically apply to commercial forests and do not take into account such specific and valuable protected areas in terms of nature as the Białowieża Forest. Those regulations are often in conflict with the regulations on nature protection, and even more so with the requirements of the convention on the protection of the world cultural and natural heritage. Therefore, it is necessary to change the national law so that, on one hand, it allows for ensuring proper protection against fires of valuable natural objects, while, on the other hand, it does not affect negatively protected values. In order to minimize the risk of fires and their spread and the loss of valuable natural values of the Białowieża Forest, it is recommended to take the following actions in the years 2020-2029:

in the field of fire protection and prevention:

1. Conducting educational activities aimed at making the local community and tourists aware of the fire hazard in the Białowieża Forest and popularizing the principles of safe use of the forest. An effective educational and information campaign should be professionally planned, conducted in the long term and addressed to various social groups, among which the local community that interacts with the Forest on a daily basis should be particularly important. It is recommended to present the existing problem of fire hazard, especially during the period of increased forest flammability (March - September), taking into account the high level of forest fire hazard (3.SZPL), on the websites of forest districts and the national park, on official social media, in local media and in the work of forest educators.
2. It is recommended to conduct long-term monitoring of the fire hazard in the Białowieża Forest, taking into account the ongoing climate changes and their impact on the effect of the decay of spruce stands (dead wood, grass cover), which enables an adequate response within the framework of the functioning fire protection system of the Forest.

3. In order to ensure safety for rescue forces on fire access roads, it is recommended to cut down dead trees (leave them on the ground) in a 50 m strip from the fire access road, in accordance with the recommendations of the UNESCO mission from 2018.
4. In order to ensure safety and maintain the accessibility of the Forest area for rescue forces, it is recommended to mow the grass in a 2 m strip along the fire access roads.
5. Due to the fire hazard generated by dead trees in the close vicinity of power lines, it is recommended to cut them down (leave them on the ground) in zones II-III, and in zone IV, depending on the needs, to cut them down (and leave them on the ground) or remove them, and to run power transmission lines underground.
6. In a strip up to 50 m wide along public roads, forest roads open to public traffic, tourist trails and elements of tourist infrastructure, in accordance with the risk assessment procedure applied by the Facility Administrators, it is permissible to fell dead trees (leaving them on the ground) in zones II-III, and in zone IV, depending on the needs dictated by safety considerations, as well as to remove them.
7. Development of principles for managing the movement of people in the Białowieża Forest, aimed at limiting access, especially in areas with an increased fire risk, during periods of increased forest fire risk.
8. Consideration of the possibility of extending the monitoring of anthropogenic pressure on the Białowieża Forest, especially in places that are attractive to tourists and areas most at risk in terms of fire, would allow for traffic control, while also being a preventive measure.
9. Taking into account local conditions in terms of low water retention, which may to some extent locally reduce the fire hazard.
10. As part of the integrated management plan for the Białowieża Forest World Heritage Site, to agree, to the extent possible, with Belarus on the principles of observing and detecting fires in the Polish part of the Forest, especially in the border zone, alerting about them and exchanging information on cross-border threats.
11. Gradual adjustment of the condition of fire access roads in the forest districts and the Białowieża National Park to the applicable regulations.

in the field of fire extinguishing:

1. Consideration of the possibility of establishing a regional alarm and dispatch point for the Polish part of the Białowieża Forest (forest districts and BPN), whose task would be to coordinate the functioning of the fire protection system.
2. Adjustment of the rules for dispatching firefighting aircraft depending on meteorological conditions and the fire origin.
3. Striving to improve the functioning and unification of the radio communications network for fire protection purposes in the forest districts and Białowieża National Park.
4. Organizing exercises of rescue services, forestry services and the national park and other entities in the field of extinguishing forest fires in the Białowieża Forest.
5. Considering the purchase of vehicles of the "all-terrain" type or Quad with good traction properties, possibly with electric drive for use in the Białowieża Forest, especially in BPN, in order to identify fire situations, verify the possibility of using water draw-off points, build fire extinguishing lines, supervise the effectiveness of water mains to supply water over long distances.
6. Considering the purchase of mobile water supply sets containing a collapsible tank with a capacity of 8-15 thousand liters, a fire pump and the necessary fittings.
7. Consideration of the possibility of equipping the State Fire Service and Volunteer Fire Department units, especially those available in the first wave, with rescue and firefighting vehicles and equipment dedicated to combatment of fires in forest areas, including light patrol and firefighting vehicles with portable equipment.
8. Use, especially in reserves and within the national park, to a greater extent, of portable equipment
9. The use of chemical extinguishing agents should be limited only to agents which are biodegradable and necessary to eliminate fires that are difficult to extinguish with water, e.g. subsurface fires (rot, peat), lying logs.
10. Preparation of "strategic water draw-off points" discussed in Chapter 2.6. for simultaneous water draw-off by more than one firefighting vehicle.

general ones

1. Consider changes in the current legal regulations on forest fire protection, which would enable a different approach to fire protection of sites that are particularly valuable in terms of nature, such as national parks and reserves, which are treated as commercial forests under the current law.

Bibliography

1. Malzahn E., Pierzgalski E., Tyszka J., Fronczak E., Stolarek A., 2014. Zmiany warunków klimatycznych i wodnych w środowisku lasów naturalnych Puszczy Białowieskiej. Raport IBL, BLP-361, Sękocin Stary.
2. Malzahn E., Zin E., Kudlewski A., Browski K., 2018. Ocena wpływu zmian czynników abiotycznych na środowisko lasów naturalnych Puszczy Białowieskiej. Raport IBL Nr 240608 Białowieża.
3. Miler A.T., 2013. Kompleksowa metodyka oceny stosunków wodnych w lasach. Wyd. Uniwersytet Przyrodniczy w Poznaniu.
4. Kolk A., Lech P., Sierota z., 1996. Określenie stref zagrożeń lasów Polski przez czynniki biotyczne. Biblioteka Monitoringu Środowiska, PIOŚ, Warszawa.
5. Szczygieł R., Kwiatkowski M., Kołakowski B., 2017. Opracowanie modeli paliw leśnych materiałów roślinnych pokrywy gleby. Raport IBL, Sękocin Stary.
6. Wielkoobszarowa inwentaryzacja stanu lasów w latach 2014-2018. Biuro Urządzania Lasu i Geodezji Leśnej, Sękocin Stary.
7. Maser C., Anderson R., Cromack K., Williams J.T., Martin R.E., 1979. Dead and down woody material. USDA Forest Service. Portland – Washinton D.C. Agriculture Handbook 553.
8. Wielkoobszarowa inwentaryzacja stanu lasów w latach 2007-2011. Biuro Urządzania Lasu i Geodezji Leśnej. Sękocin Stary.
9. Castellnou Riban H., Garcia Hernandez A., 2018. Incendios como bombas atomicas. El Pais https//elgais.com.

Other sources

1. Karol Wiler, Paweł Wcisło *„Ochrona lasów przed pożarami”*, Centrum Informacyjne Lasów Państwowych, 2013 r.
2. *„Zasady organizowania działań ratowniczych” [“Principles for organizing rescue operations”]*, Komenda Główna PSP, 2013
3. *„Zasady organizacji łączności, alarmowania, powiadamiania, dysponowania oraz współdziałania na potrzeby działań ratowniczych” [“Principles of organizing communication, alarming, notifying, dispatching and cooperation for the needs of rescue operations”]*, Komenda Główna PSP, 2016
4. *„Metodyka postępowania podczas organizacji łączności na potrzeby kierującego działaniem ratowniczym” [“Methodology of conduct when organizing communications for the needs of the rescue operation manager”]*, Komenda Główna PSP, 2016
5. *„Zasady organizacji Centralnego Odwodu Operacyjnego krajowego systemu ratowniczo-gaśniczego” [“Principles of organizing the Central Operational Reserve of the national rescue and firefighting system”]*, Komenda Główna PSP, 2018

6. *„Instrukcja ochrony przeciwpożarowej lasu" ["Forest Fire Protection Instruction"]*, Dyrekcja Generalna Lasów Państwowych, 2012.
7. *„Sposoby postępowania na wypadek powstania pożaru, klęski żywiołowej lub innego miejscowego zagrożenia" ["Methods of action in the event of a fire, natural disaster or other local threat"]*, Nadleśnictwo Białowieża, 2019
8. *„Sposoby postępowania na wypadek powstania pożaru, klęski żywiołowej lub innego miejscowego zagrożenia" ["Methods of action in the event of a fire, natural disaster or other local threat"]*, Nadleśnictwo Browsk, 2019
9. *„Sposoby postępowania na wypadek powstania pożaru, klęski żywiołowej lub inengo miejscowego zagrożenia" ["Methods of action in the event of a fire, natural disaster or other local threat"]*, Nadleśnictwo Hajnówka, 2019
10. *„Sposoby postępowania na wypadek powstania pożaru lasu dla obszarów leśnych obrębu ochronnego Rezerwat" ["Methods of action in the event of a forest fire for the forest areas of the Reserve protection zone"] Białowieża National Park, 2019,*

List of tables

Table 1. Occurrence of fires in the Białowieża Forest in 2000-2024 9
Table 2. Number of points according to the criteria for determining forest fire hazard according to the classification method as of 2012 13
Table 3. Flammability classes of tree stands depending on habitat forest and soil cover types 15
Table 4. The area of Białowieża Forest tree stands according to flammability classes [ha]. 17
Table 5. Thickness of spruce trees infested by the bark beetle and the area of dead stands in 2012–2019 19
Table 6. Calculation results of the average fire load in 2012-2019 20
Table 7. Calculation results of the increasing average fire load in 2012-2019 20
Table 8. The share of dead wood in the Białowieża Forest depending on the species and the degree of decomposition in 2016 26
Table 9. Share of dead wood in the Białowieża Forest depending on species and degree of decomposition in 2017 27
Table 10. Share of dead wood in the Białowieża Forest depending on species and degree of decomposition in 2018 27
Table 11. Results of field inventory of tree stands with soil cover generating a high fire hazard – 2016 28
Table 12. Averaged fire load for selected soil cover types 28
Table 13. Field inventory results for the area of stands with soil cover generating a high fire hazard – 2019 29
Table 14 Estimated classification of organic soil areas in the Białowieża Forest in terms of their thickness 30
Table 15. Number of people visiting Białowieża National Park in 2015-2023 31
Table 16. Protective tasks and projects carried out by organizational units of PGL LP depending on the level of forest fire risk 32
Table 17. List of extinguishing equipment bases 37
Table 18. Condition of fire access roads – results of the inventory conducted in 2019 40
Table 19. Draw-off points broken down by categories 45
Table 20. Estimated fire sizes at the time of commencement of firefighting operations and required minimum amounts of forces and resources based on modelling 49
Table 21. Share of tree stand area depending on the expected fire area 49
Table 22. Equipment of firefighting vehicles and special units of the State Fire Service in the Hajnówka district 56
Table 23. Equipping Volunteer Fire Department units included in the KSRG in the Hajnówka district with firefighting vehicles 58
Table 24. Equipping the Volunteer Fire Department units outside the KSRG in the Hajnówka district and the Military Fire Service (WSP) with firefighting vehicles 58
Table 25. Equipping the State Fire Service units in the Podlaskie Province with fire-fighting vehicles 59
Table 26. List of specialist rescue and fire-fighting equipment in the resources of the State Fire Service in the Podlaskie Province 60
Table 27. List of forces and resources of the "BIAŁYSTOK" Firefighting Group 63
Table 28. List of forces and resources of the Logistics Platoon "BIAŁYSTOK" 63
Table 29. WOO List of forces and resources of the WOO Firefighting Platoons 64

List of figures

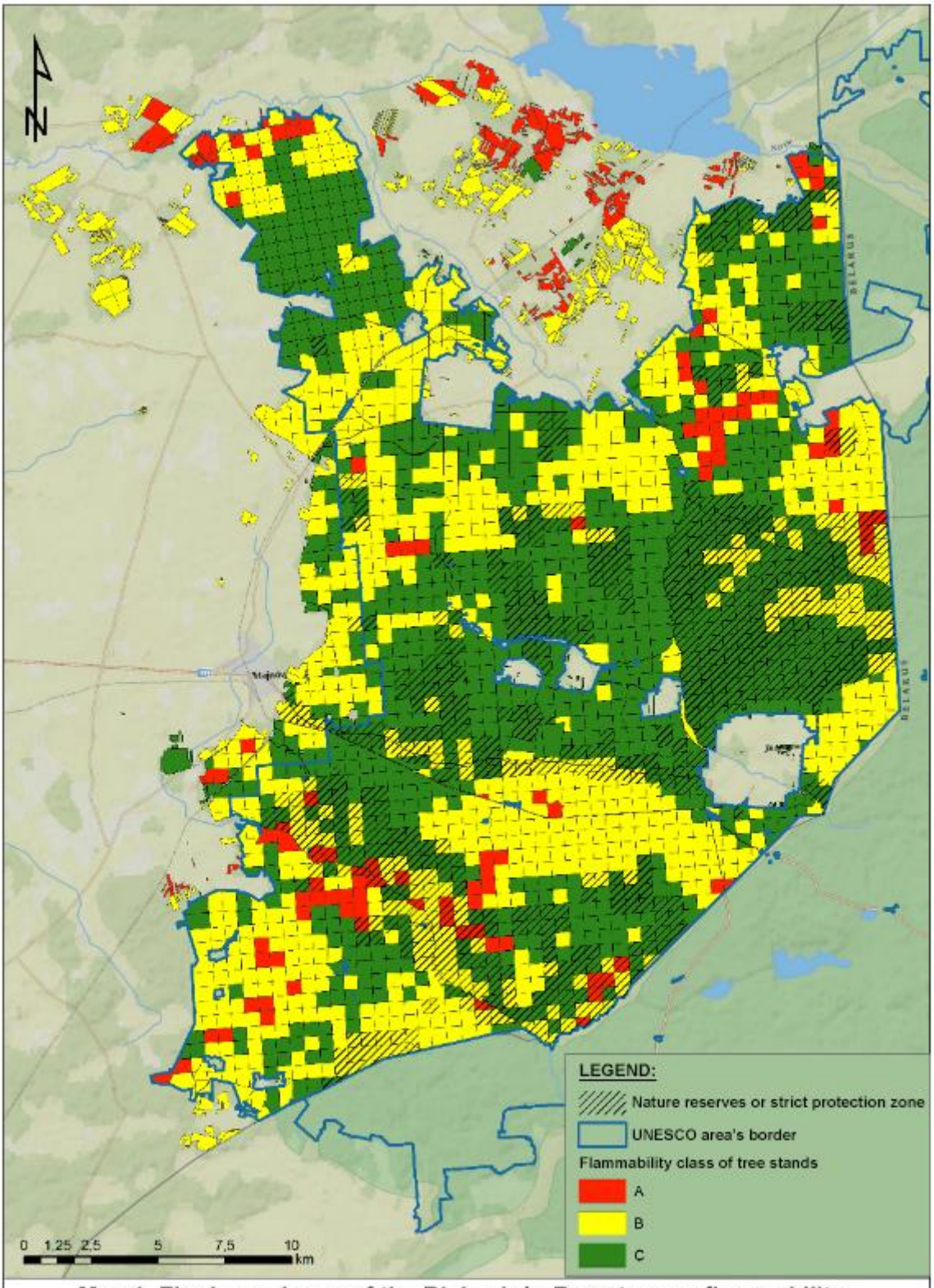
Figure 1. The range of the Białowieża Forest Transboundary World Heritage Site 7
Figure 2. Breakdown of forest fire density in the Białowieża Forest in 2007-2019 by cause..... 10
Figure 3. Spatial distribution of forest fires in the Białowieża Forest in 2007-2019 by cause..... 11
Figure 4. The area of the Białowieża Forest by forest fire hazard category as of 2012 14
Figure 5. Dead trees in the initial phase of stand decay pose a significant fire hazard due to the presence of large amounts of fire-active biomass. 23
Figure 6. Dead trees lying with small, dry twigs covered with grass pose a major threat. 23
Figure 7. Medium fire hazard occurs when there is a loss of fine flammable material, causing a lack of linear continuity that allows fires to spread easily. 24
Figure 8. Dead wood in an advanced stage of decomposition generates a minimal fire hazard, due to its structure which practically excludes the possibility of initiating combustion and limits the spread of fire. 25
Figure 9. Model course of potential fire hazard for dead stands of the Białowieża Forest in 2012 – 2029 26
Figure 10. Range of the forecasting zone 1-E 33
Figure 11. Proposed marking of fire access roads (e.g. on characteristic trees)..... 42
Figure 12. Deployment of important specialized equipment in the Podlaskie province 66
Figure 13. Location of the Forest Air Bases and operational landing site in Narew..... 68

List of acronyms

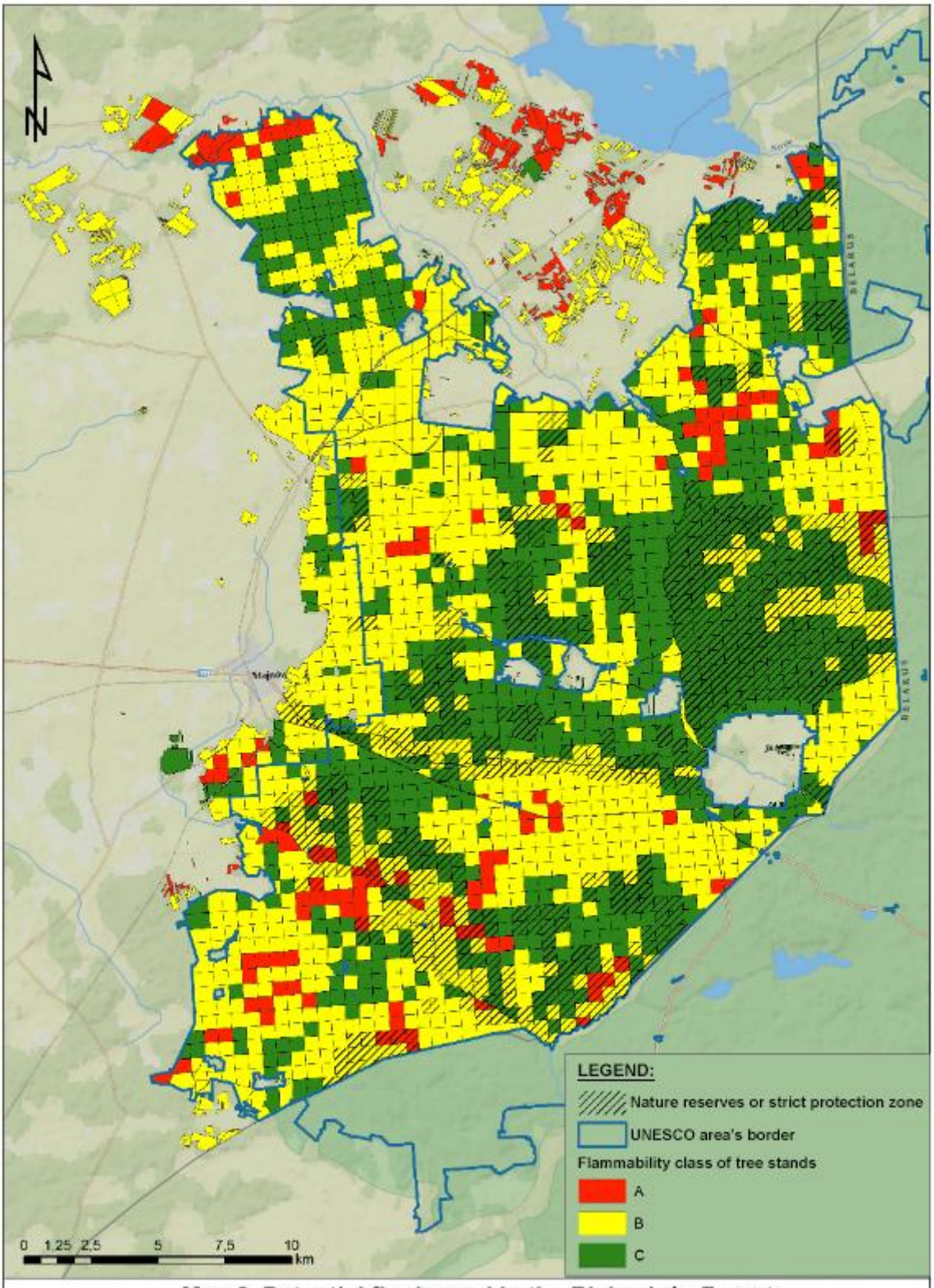
BPN	Białowieski Park Narodowy [Białowieża National Park]
COO	Centralny Odwód Operacyjny [Central Operational Reserve]
JRG	Jednostka Ratowniczo Gaśnicza [Rescue and Firefighting Unit]
KDR	Kierujący Działaniem Ratowniczym [Rescue Operations Manager]
KM	Komenda Miejska [City Headquarters]
KP	Komenda Powiatowa [County Headquarters]
KSRG	Krajowy System Ratowniczo Gaśniczy [National Rescue and Firefighting System]
KW	Komenda Wojewódzka [Provincial Headquarters]
KZPL	Kategoria Zagrożenia Pożarowego Lasu [Forest Fire Hazard Category]
LP	Lasy Państwowe [State Forests]
MSW	Ministerstwo Spraw Wewnętrznych [Ministry of Internal Affairs]
OSP	Ochotnicza Straż Pożarna [Volunteer Fire Department]
PAD	Punkt Alarmowo Dyspozycyjny [Alarm and Dispatch Point]
PPSiŚ	Punkt Przyjęcia Sił i Środków [Forces and Resources Acceptance Point]
PSP	Państwowa Straż Pożarna [State Fire Service]
PSP	Państwowa Straż Pożarna [State Fire Service]
RDLP	Regionalna Dyrekcja Lasów Państwowych [Regional Directorate of State Forests]
RSR	Radiowa Sieć Retransmisyjna [Radio Retransmission Network]
SZPL	Stopień Zagrożenia Pożarowego Lasu [Forest Fire Threat Level]
WOO	Wojewódzki Odwód Operacyjny [Provincial Operational Reserve]

Symbols of rescue and fire-fighting equipment

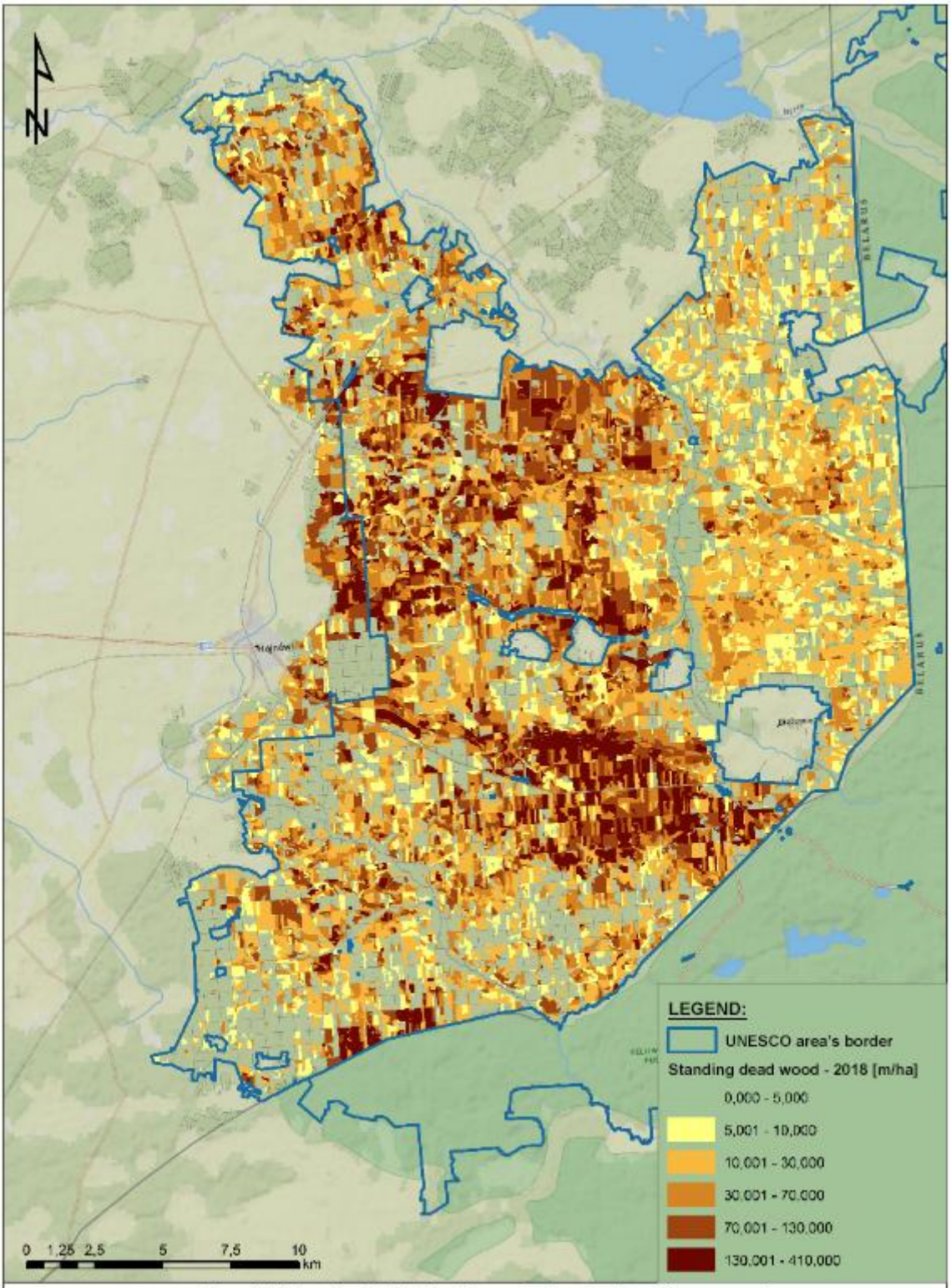
AP	Agregat pompowy [Pump unit]
DWP	Działko wodno pianowe [Water and foam cannon]
GBA	Samochód gaśniczy średni [Medium firefighting vehicle]
GCBA/GCBM	Samochód gaśniczy ciężki [Heavy firefighting vehicle]
SCKn	Samochód ciężki – kontener [Heavy vehicle – container]
SDł	Samochód dowodzenia i łączności [Command and Communications Vehicle]
SLKw	Samochód kwatermistrzowski lekki [Light firefighting staff and equipment transport vehicle]
SLOp	Samochód lekki operacyjny [Light operational vehicle]
SLRR	Samochód lekki ratowniczo rozpoznawczy [Light rescue and reconnaissance vehicle]



Map 1. Fire hazard map of the Białowieża Forest area - flammability classes of tree stands by divisions as of 2019

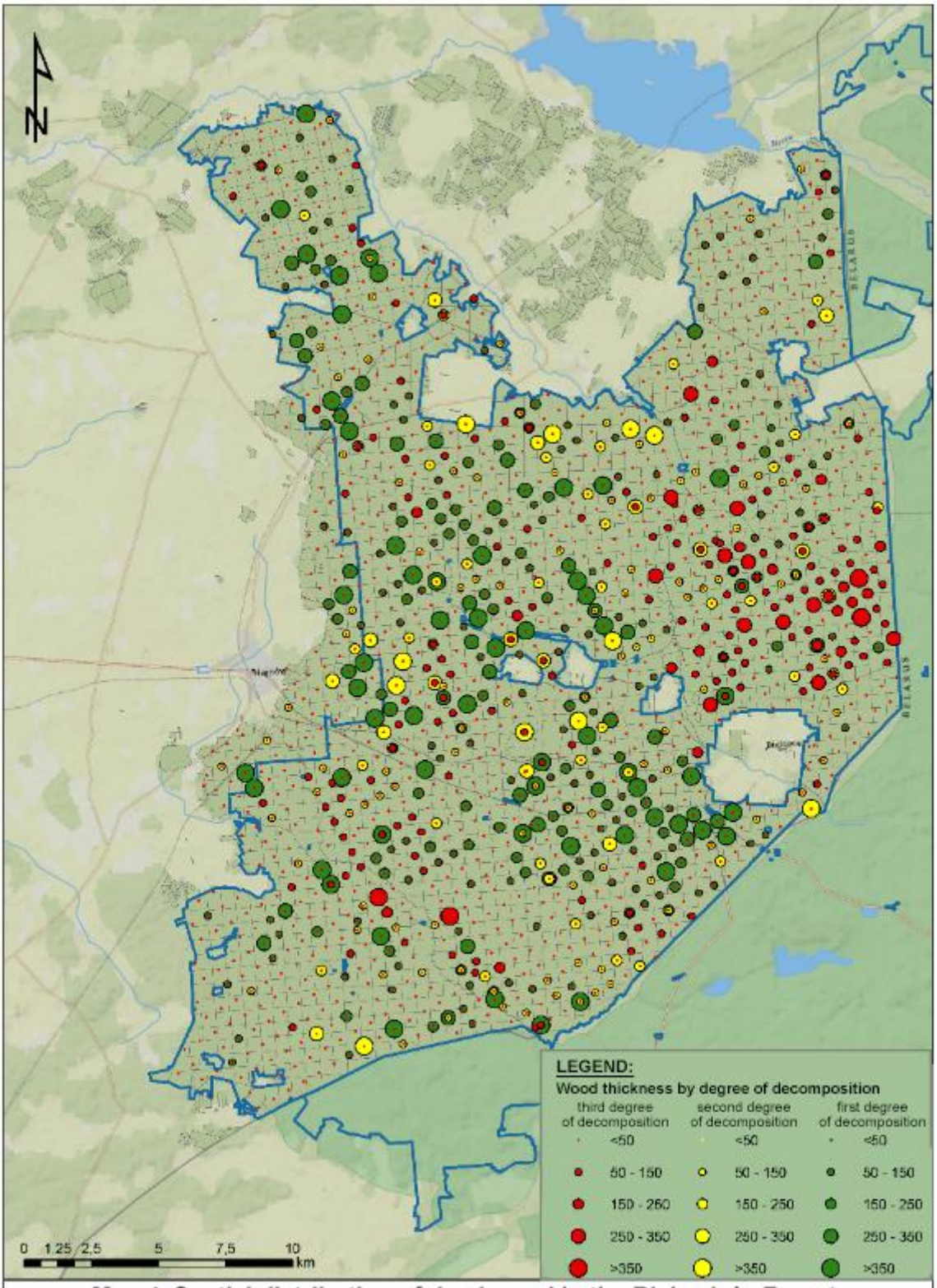


Map 2. Potential fire hazard in the Białowieża Forest
- flammability classes of tree stands by divisions

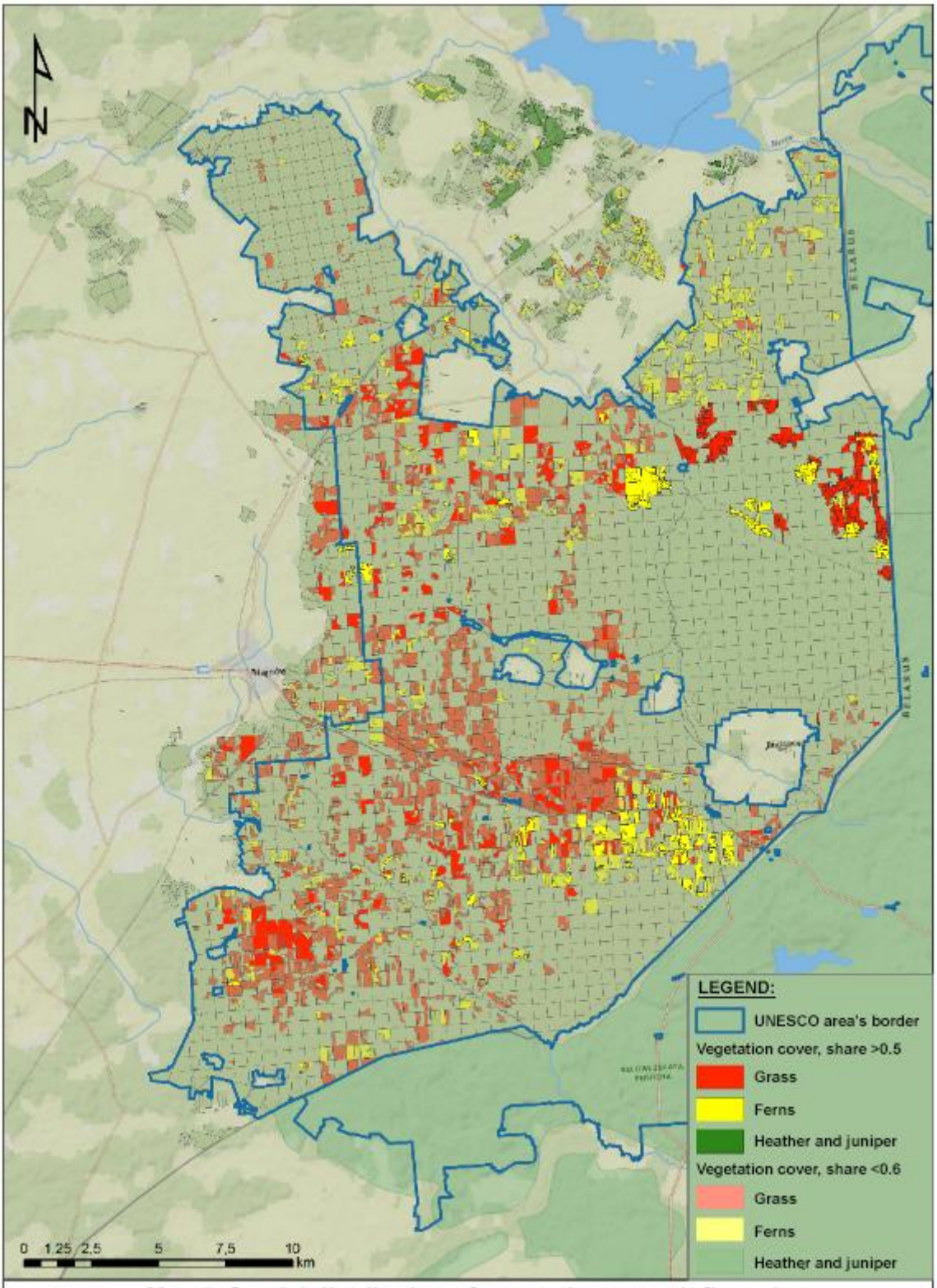


Map 3. Spatial distribution of dead standing wood in the Białowieża Forest - as of August 2018

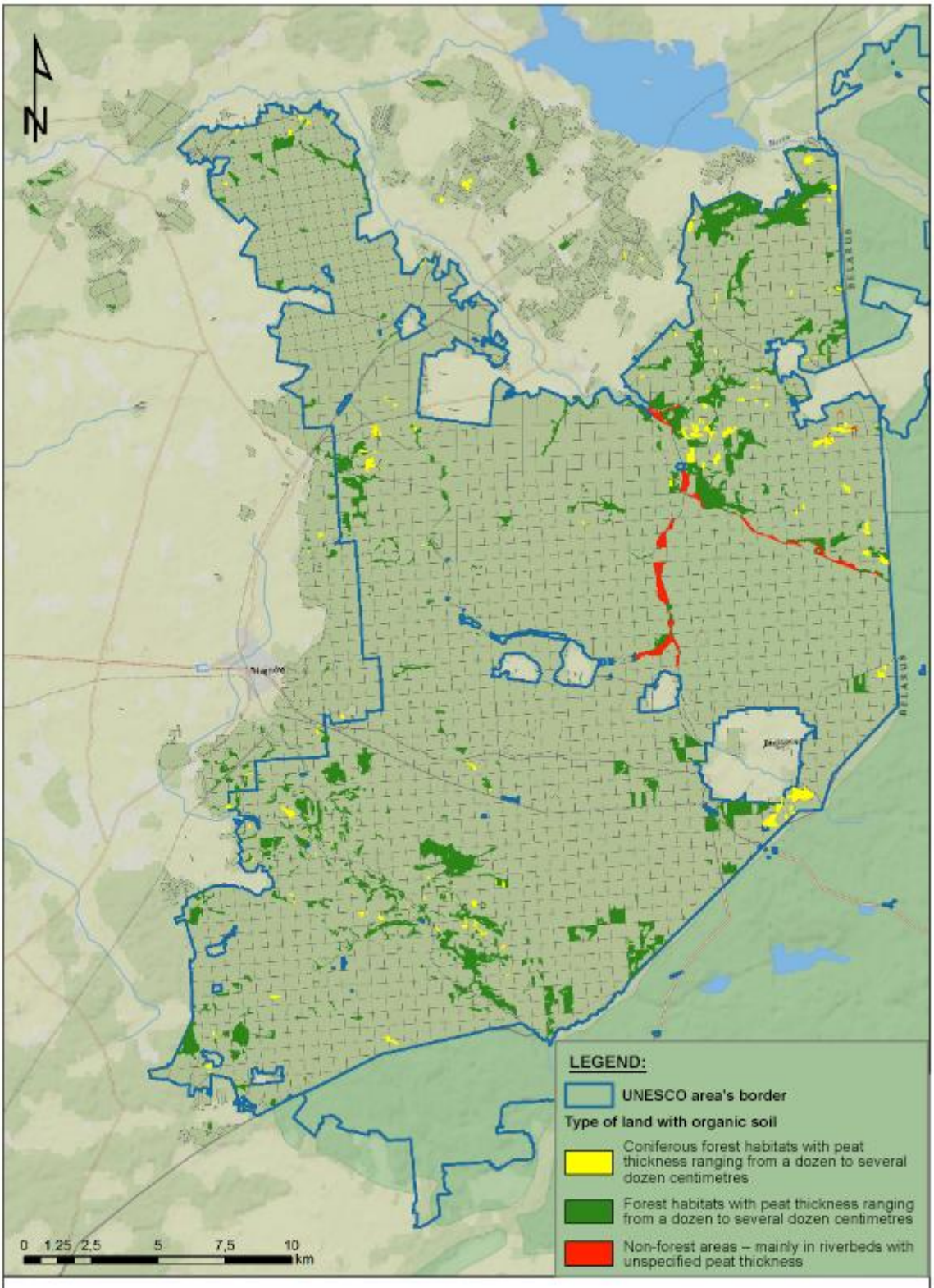
(data from ALS aviation scanning performed under the Life+ ForBioSensing project)



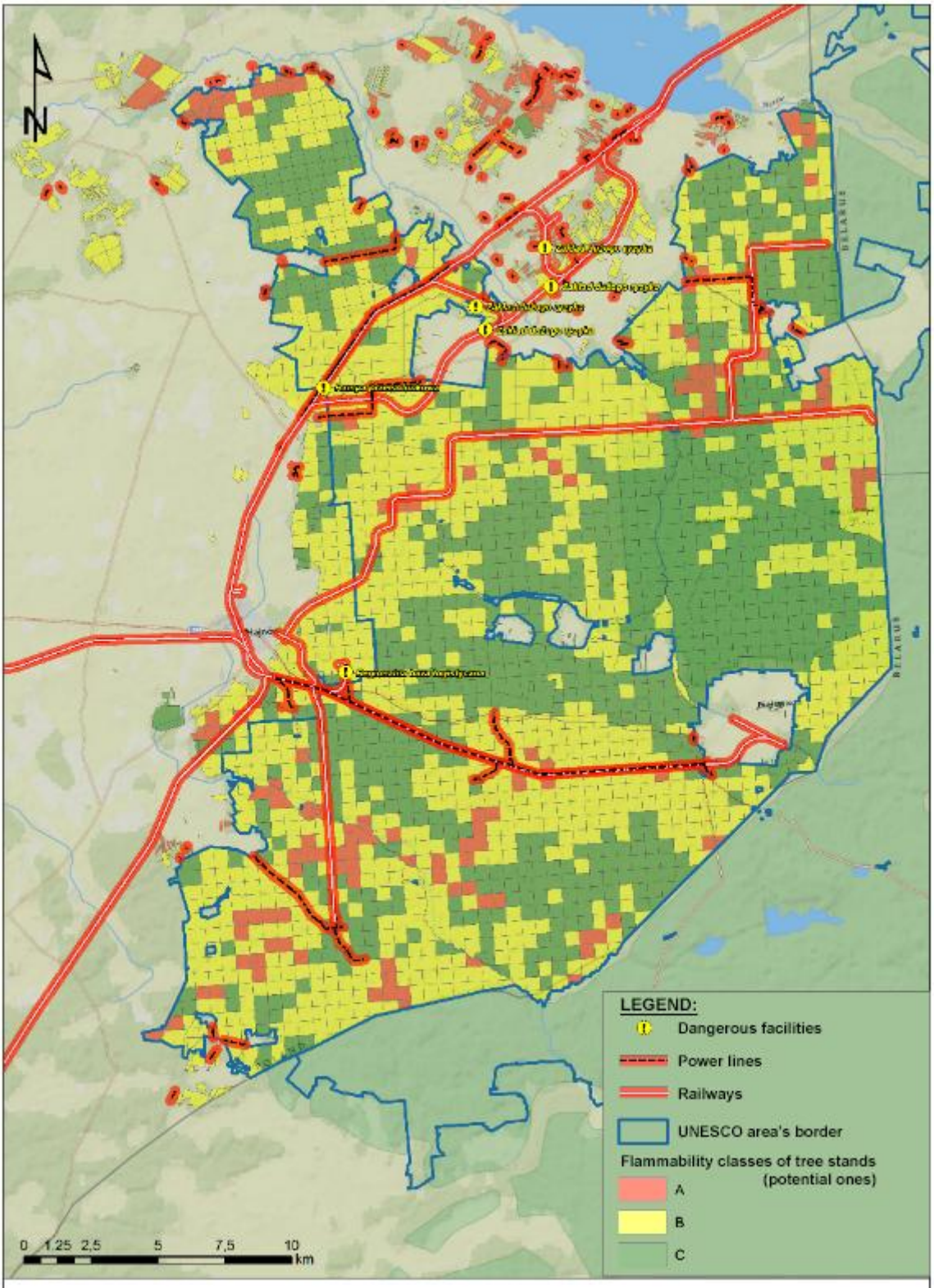
Map 4. Spatial distribution of dead wood in the Białowieża Forest according to the degree of decomposition



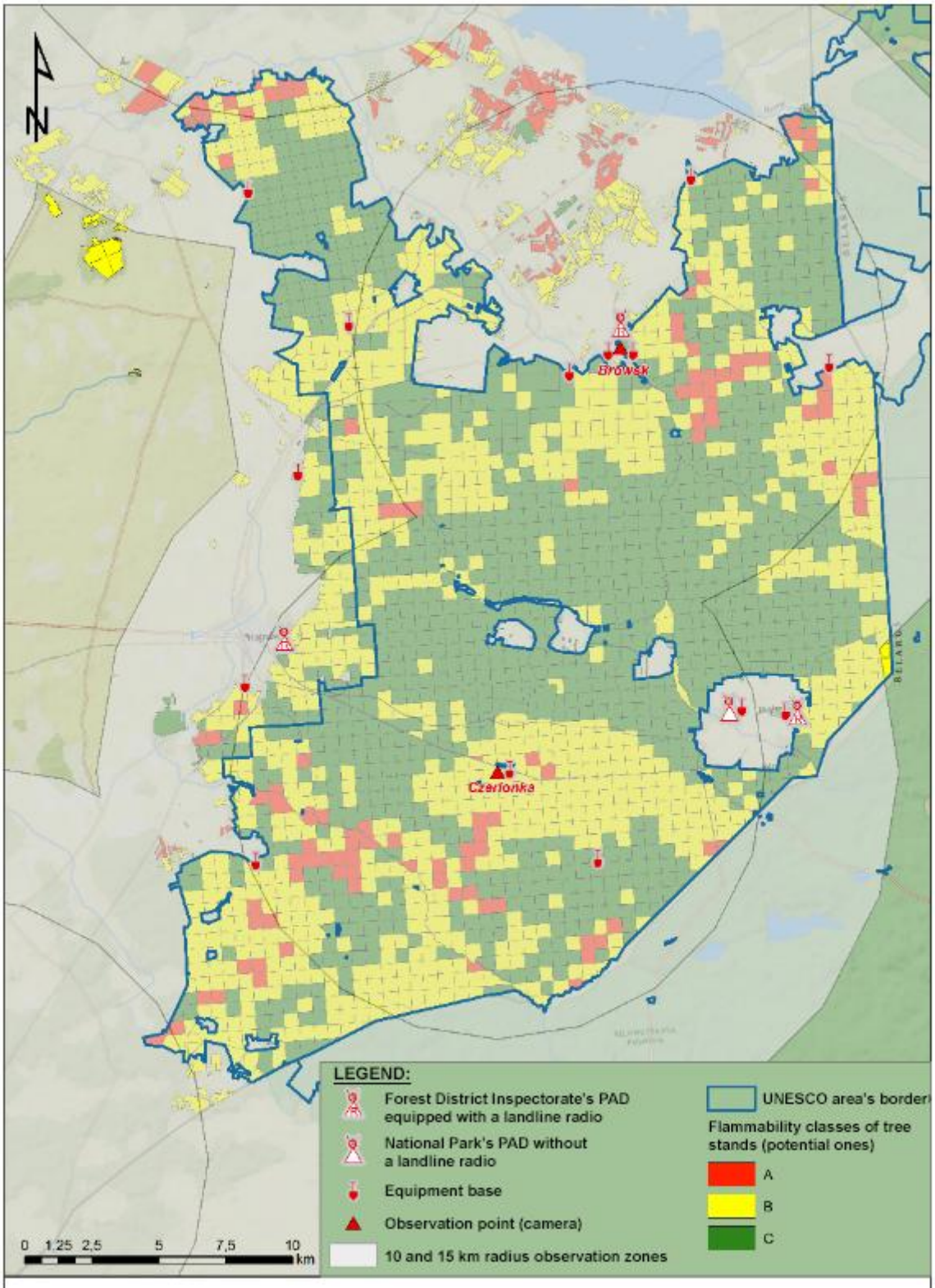
Map 5. Spatial distribution of vegetation types influencing the increase in forest fire risk in 2019



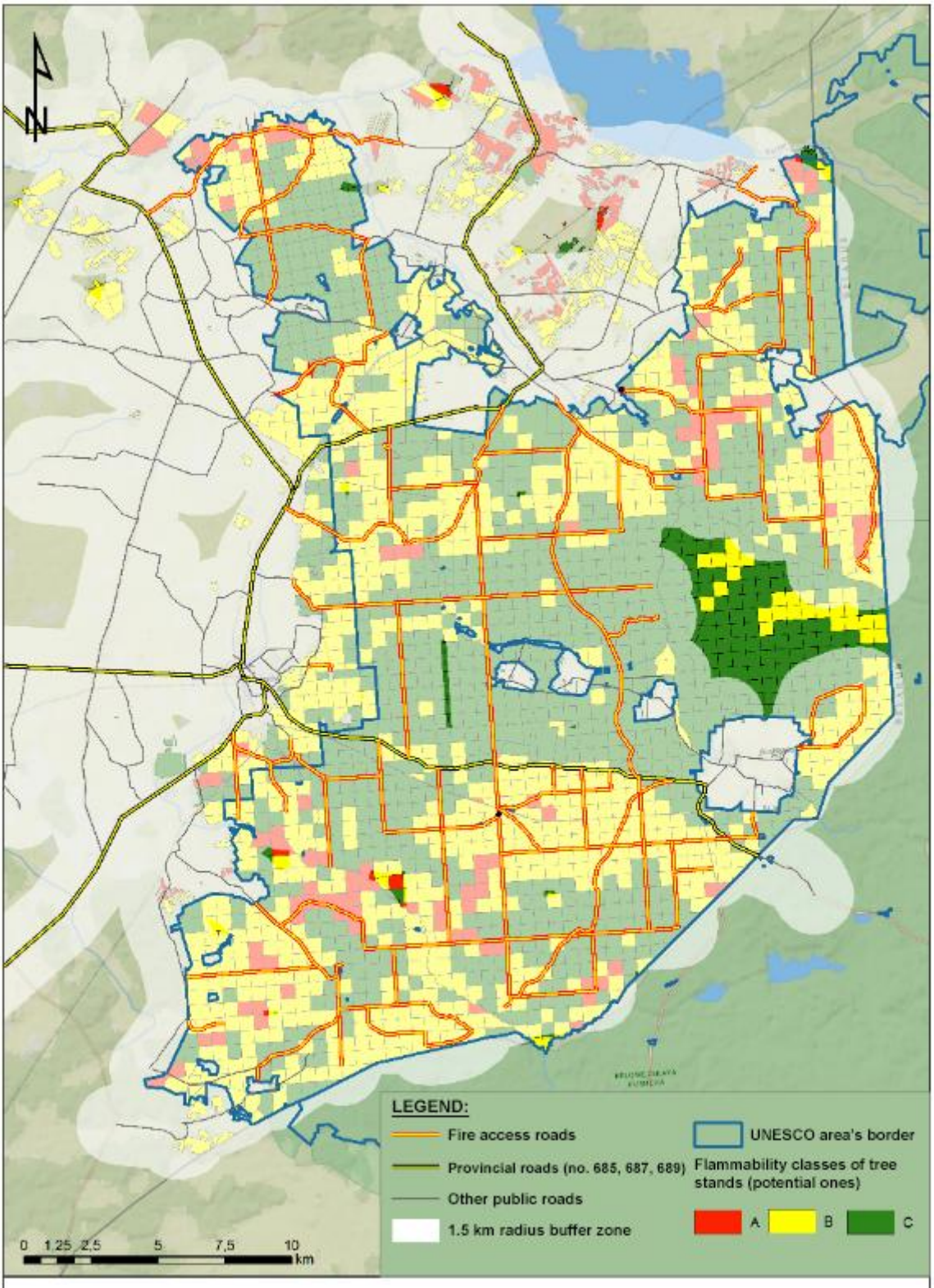
Map 6. Spatial distribution of peat bogs in the Białowieża Forest



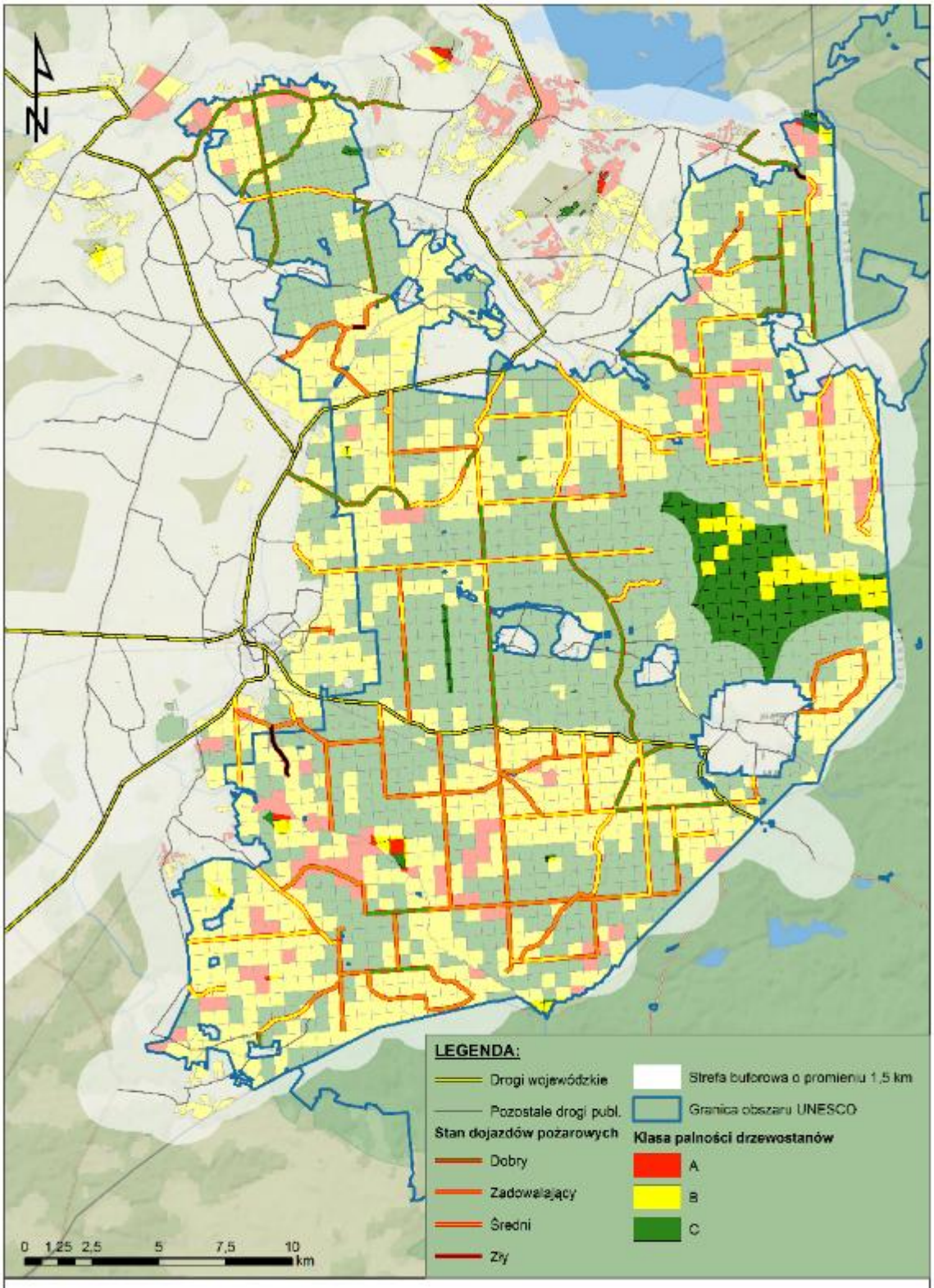
Map 7. Other factors posing a fire hazard



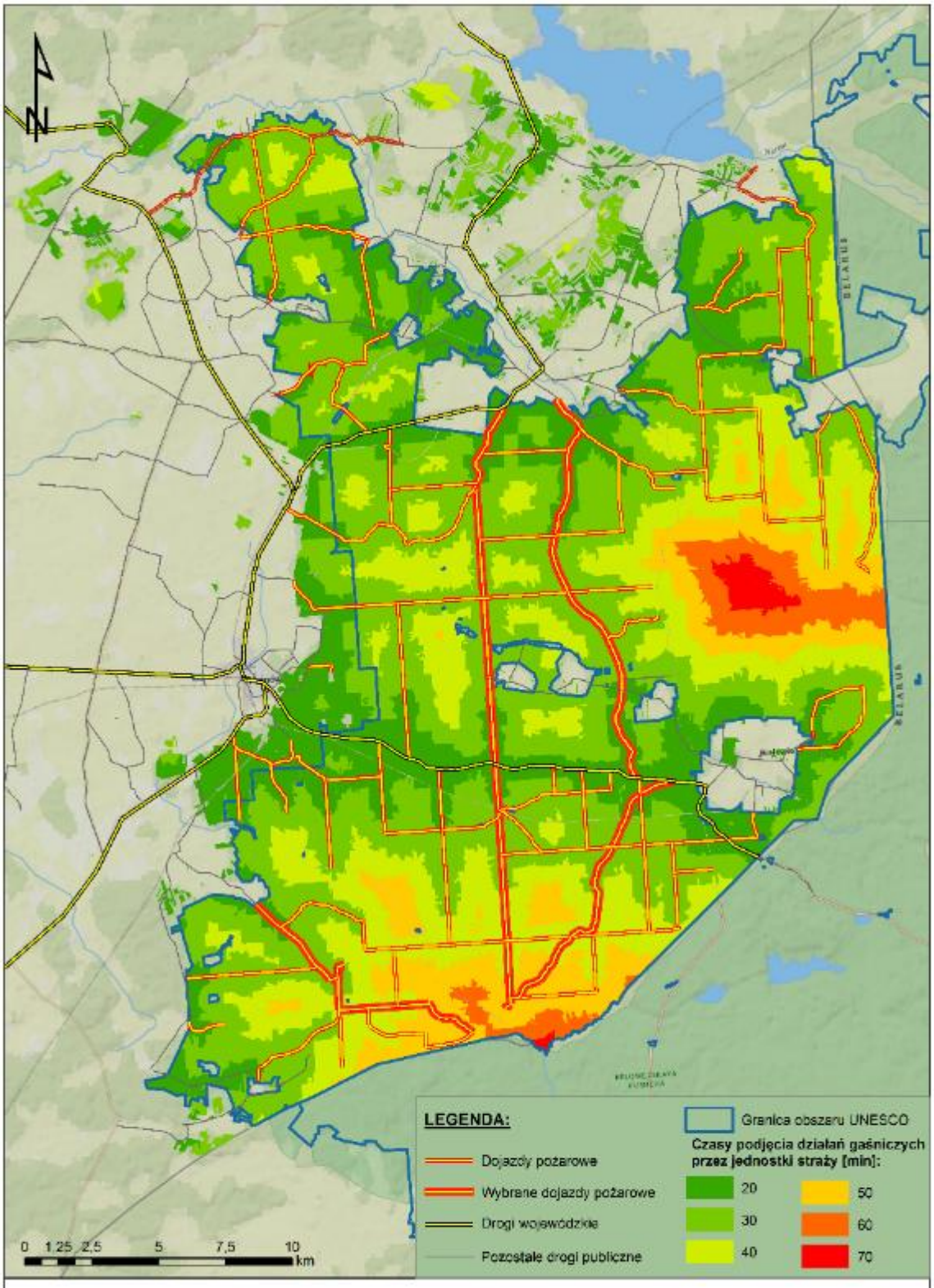
Map 8. Elements of the fire protection system



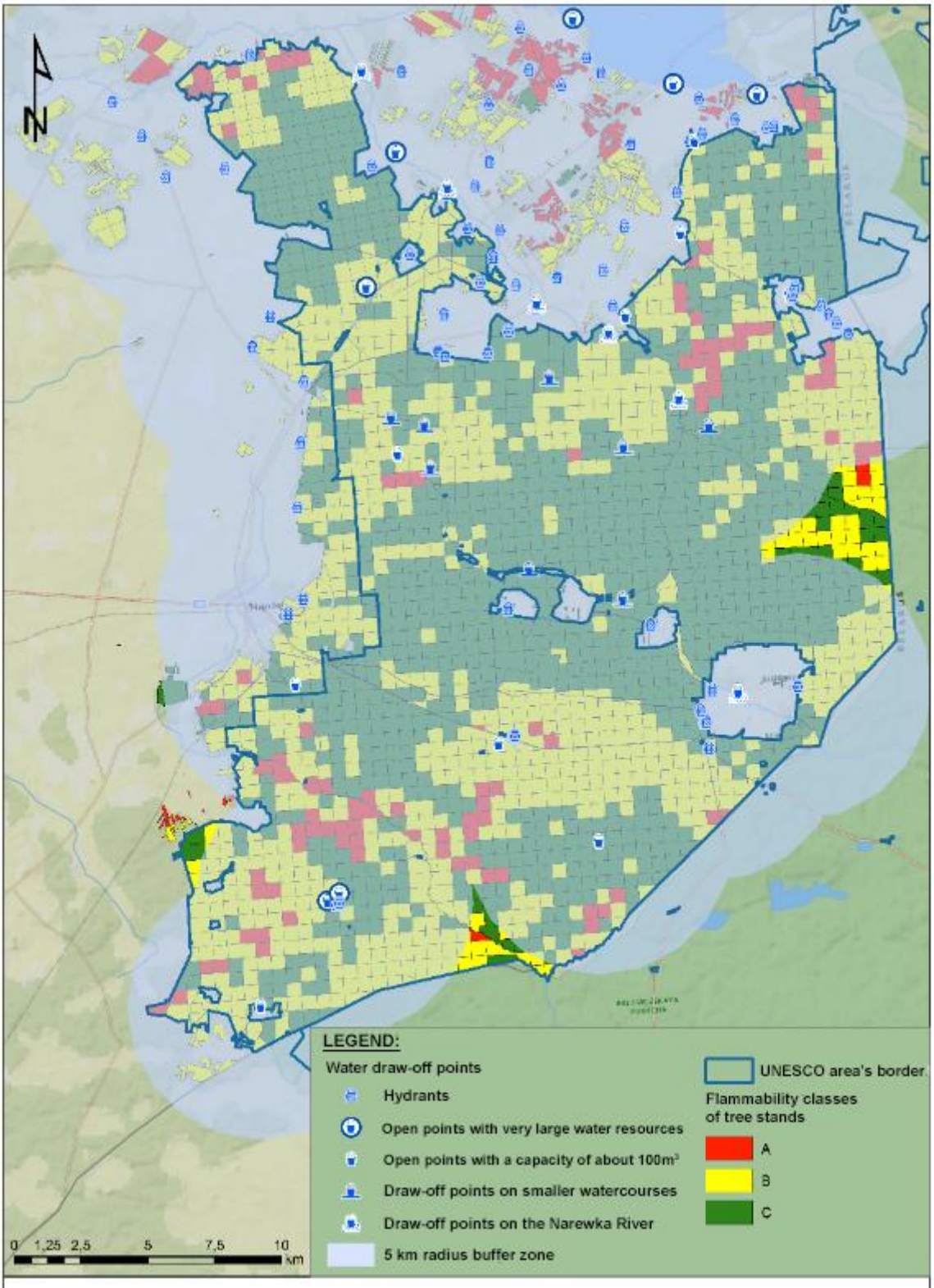
Map 9. Coverage the Białowieża Forest area with a communication network



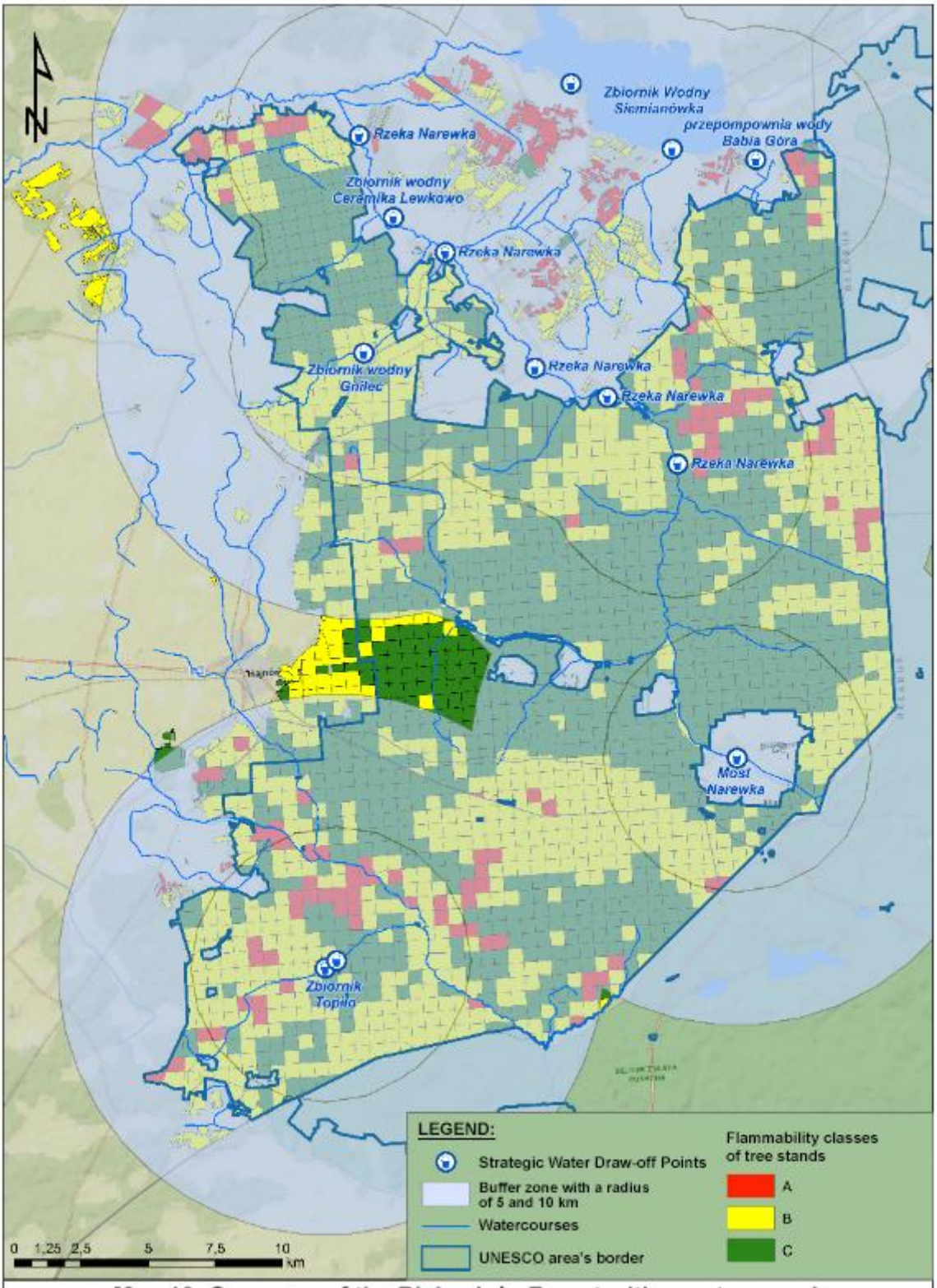
Mapa 10. Dojazdy pożarowe według klas przejezdności



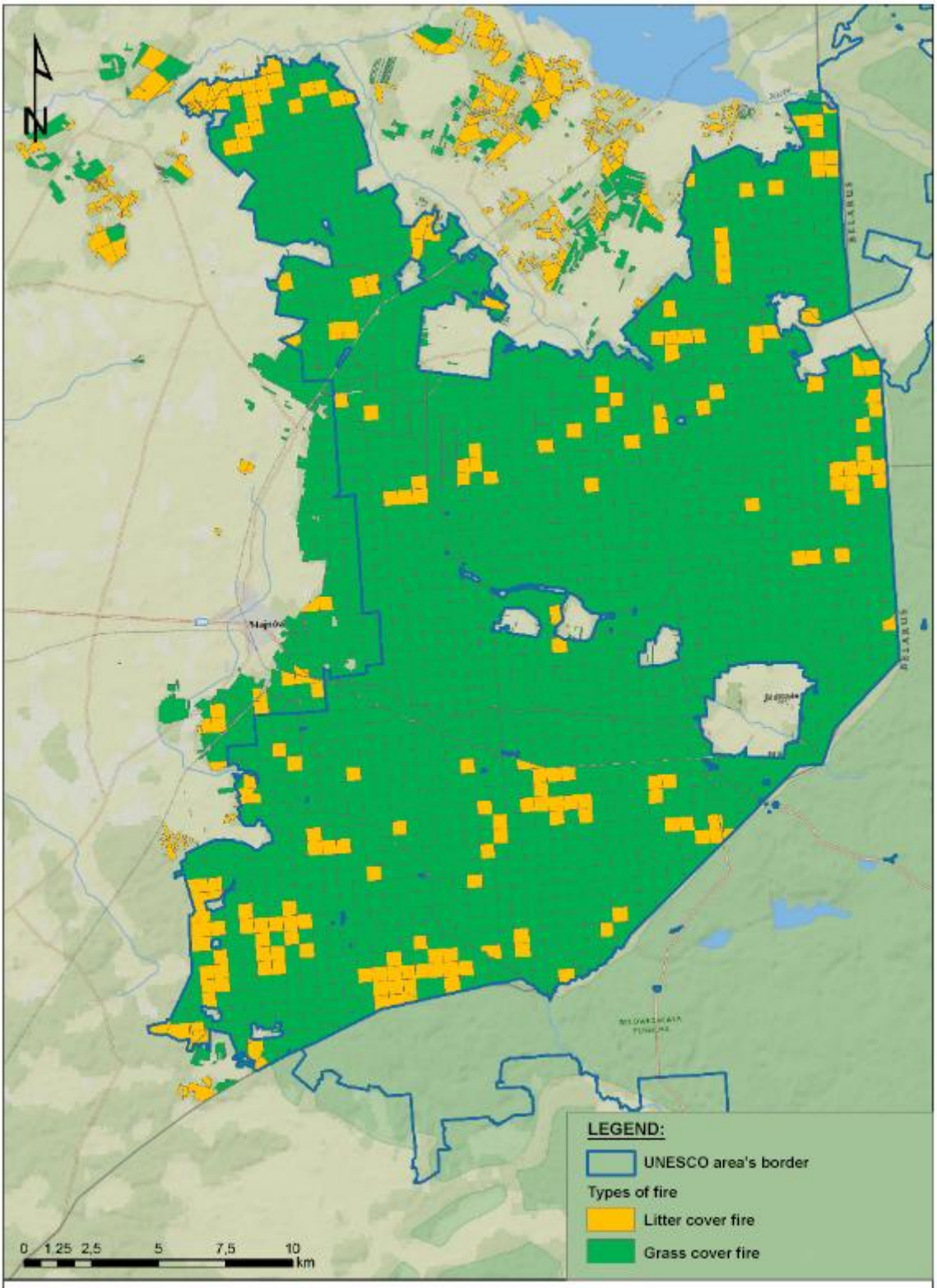
Mapa 11. Analiza pokrycia siecią komunikacyjną terenu Puszczy Białowieskiej



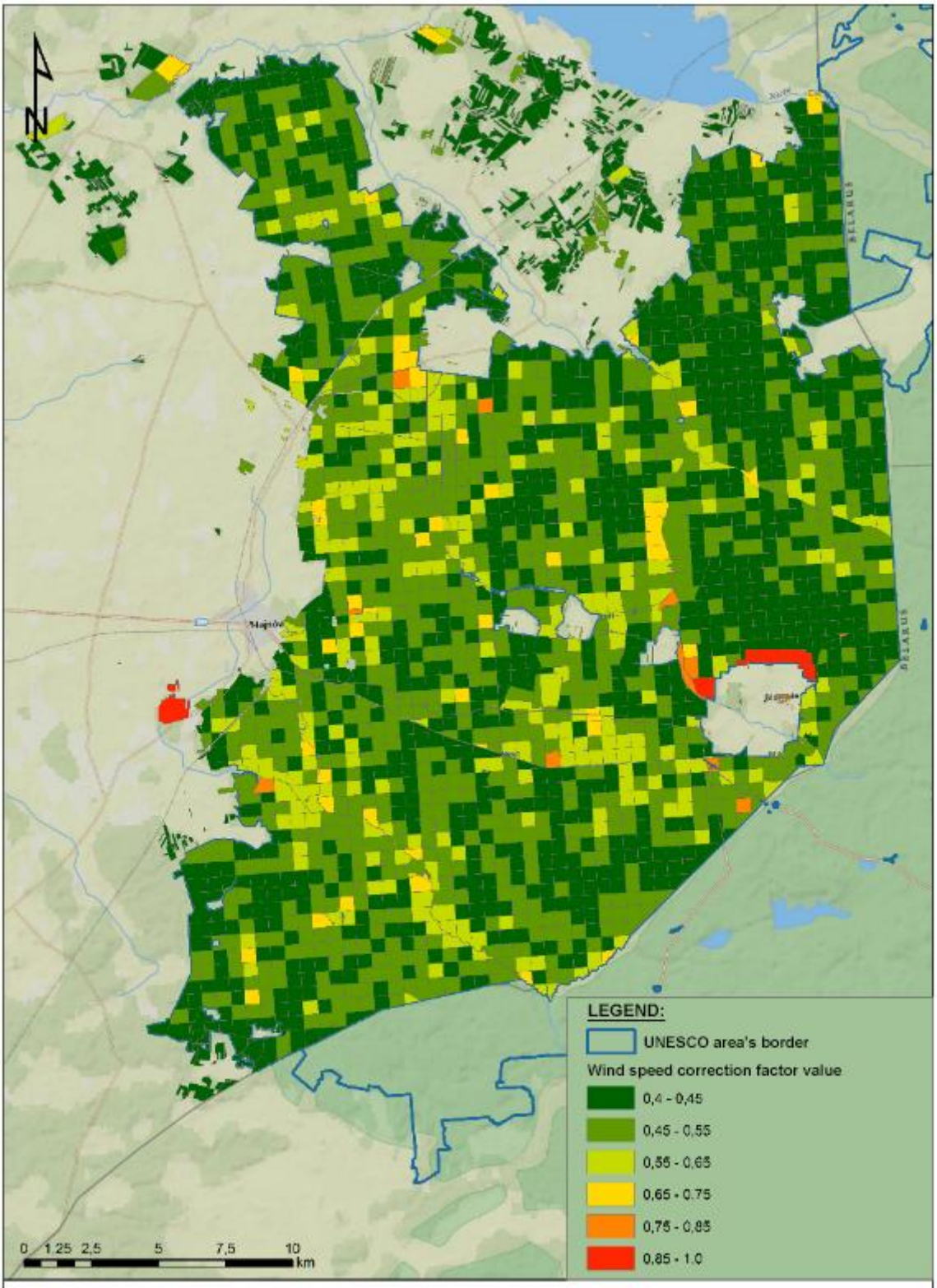
Map 12. Coverage of the Białowieża Forest with a water supply network



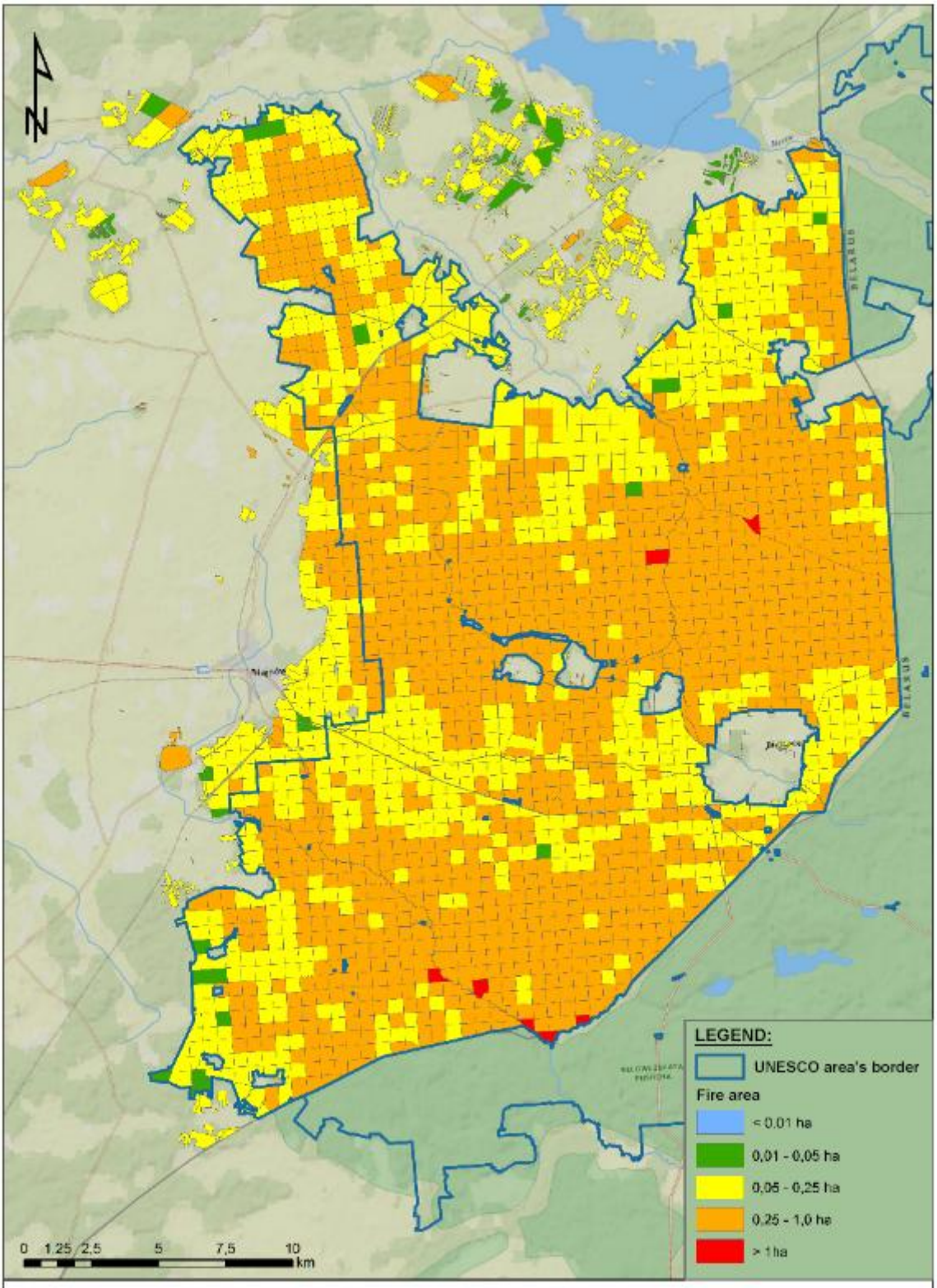
Map 13. Coverage of the Białowieża Forest with a water supply network – strategic points



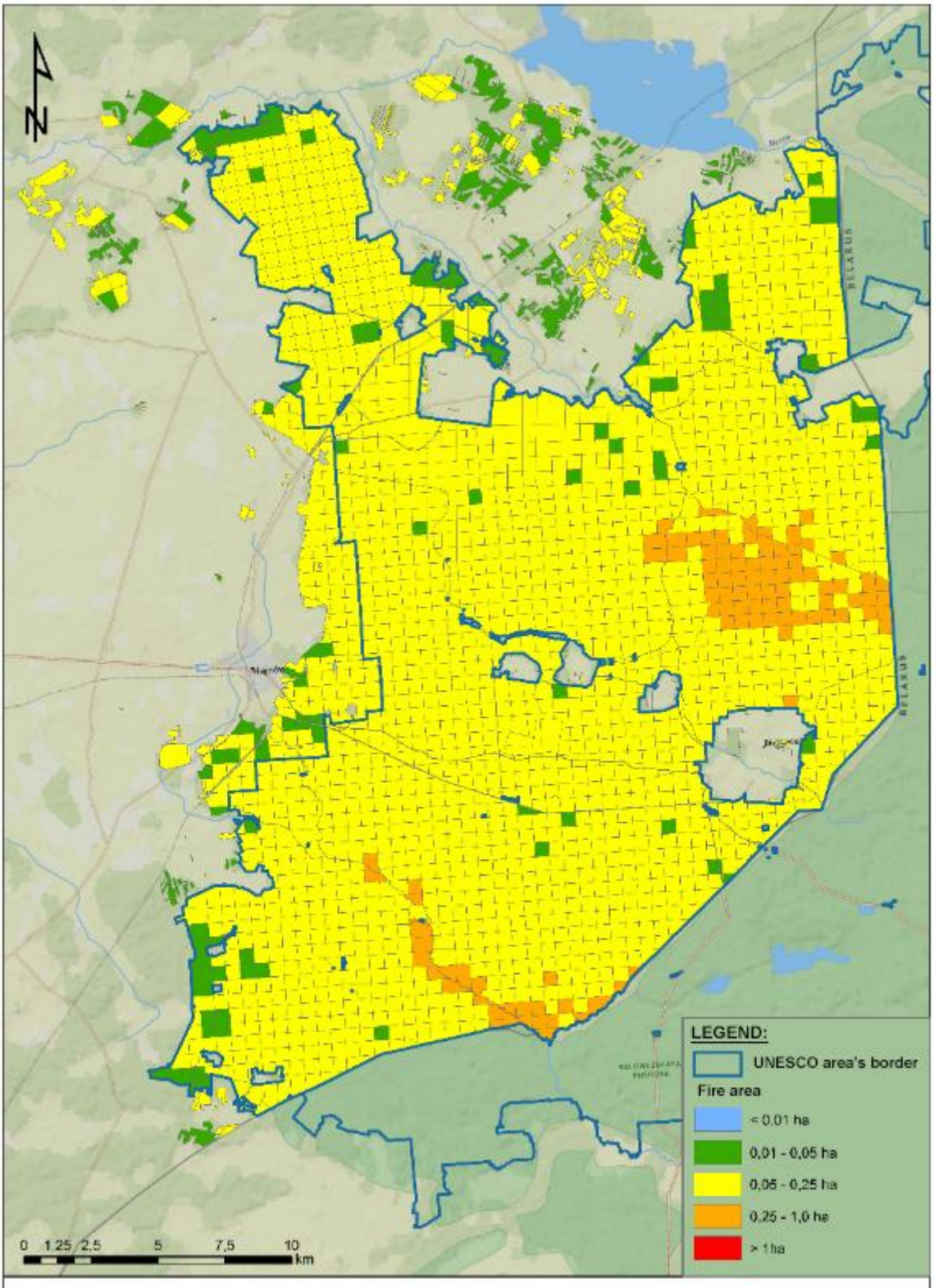
Map 14. Types of fire



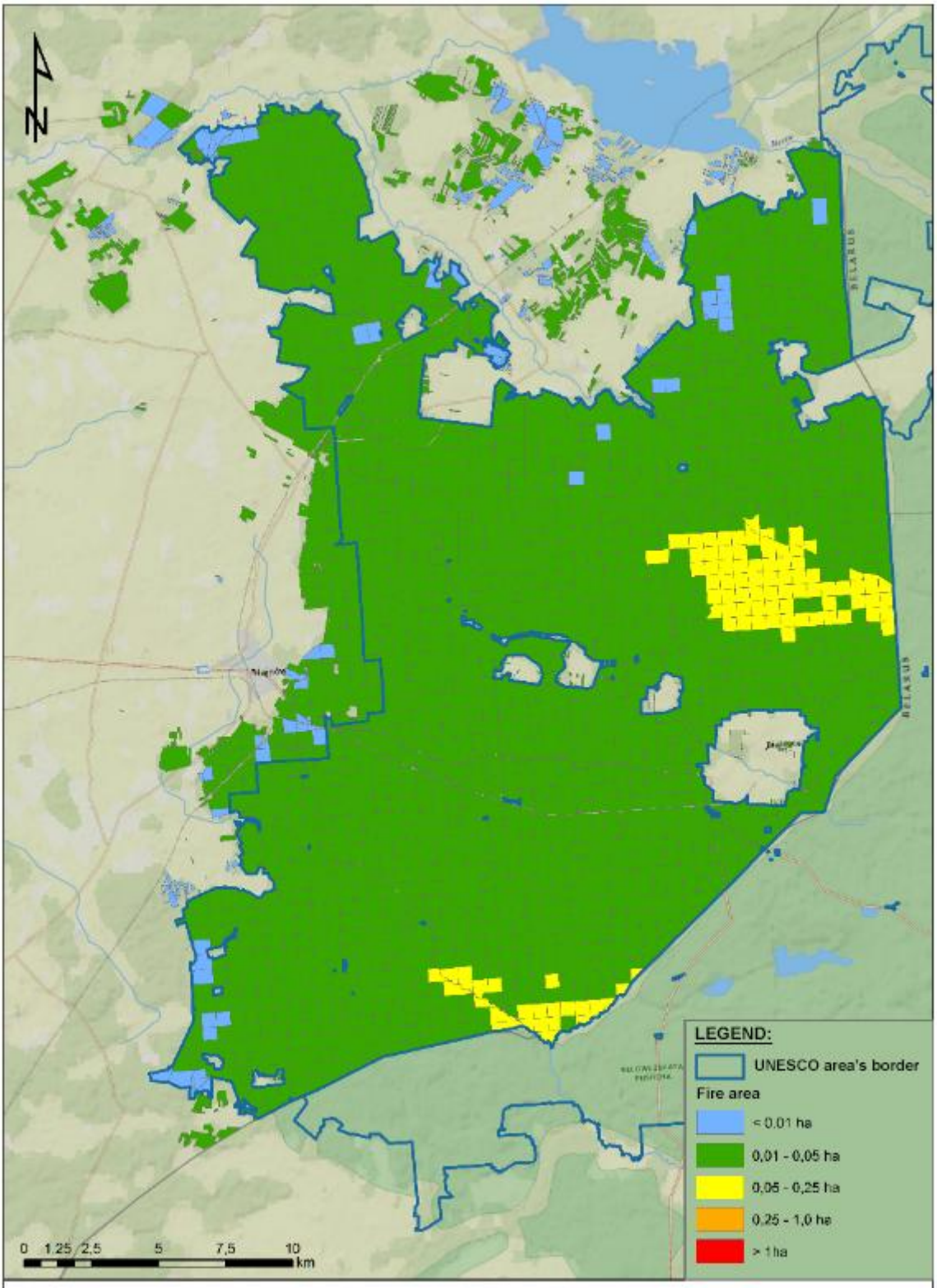
Map 15. Wind speed correction factor



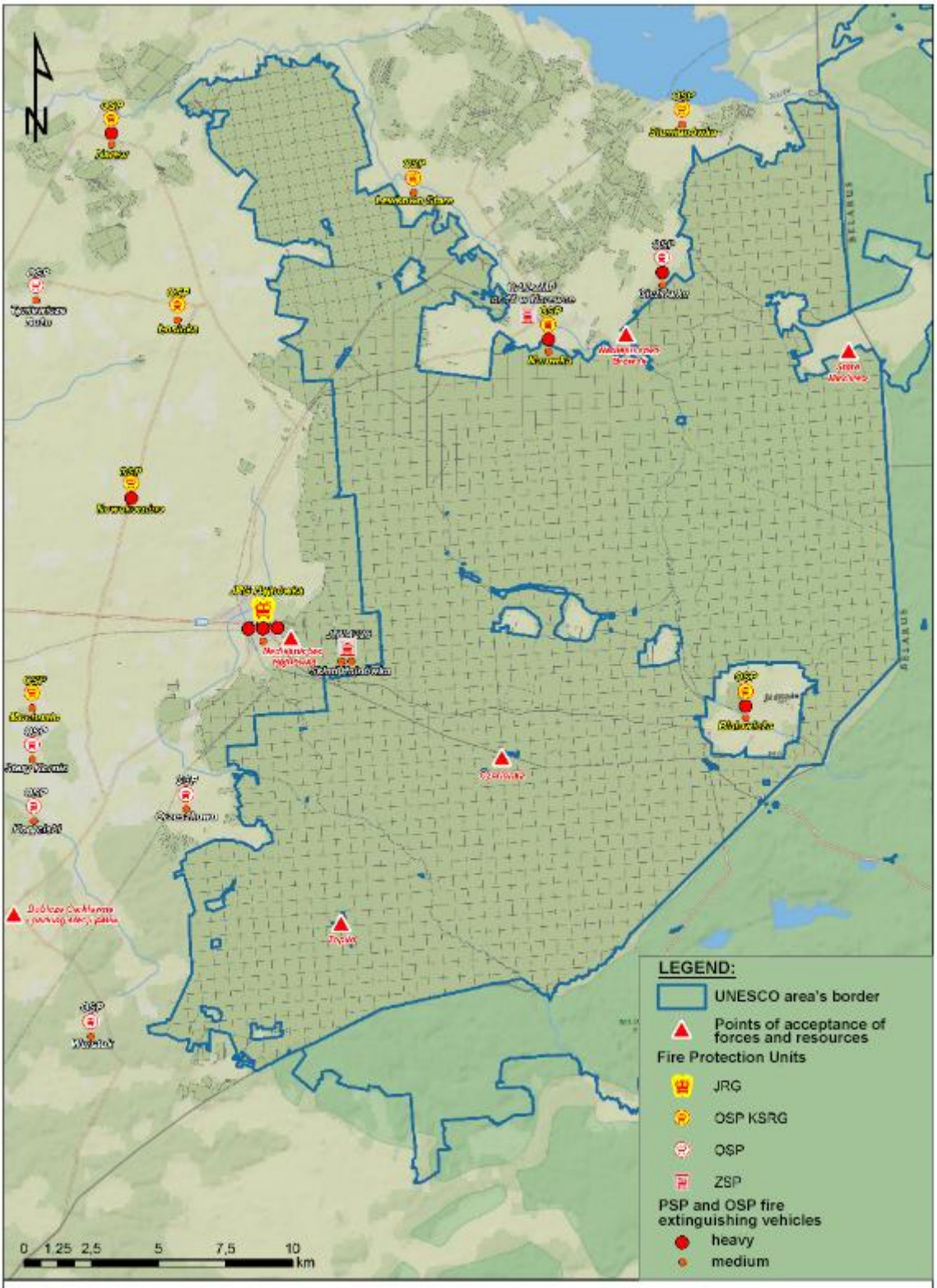
Map 16. Fire sizes at 12% litter moisture and 5m/s wind speed



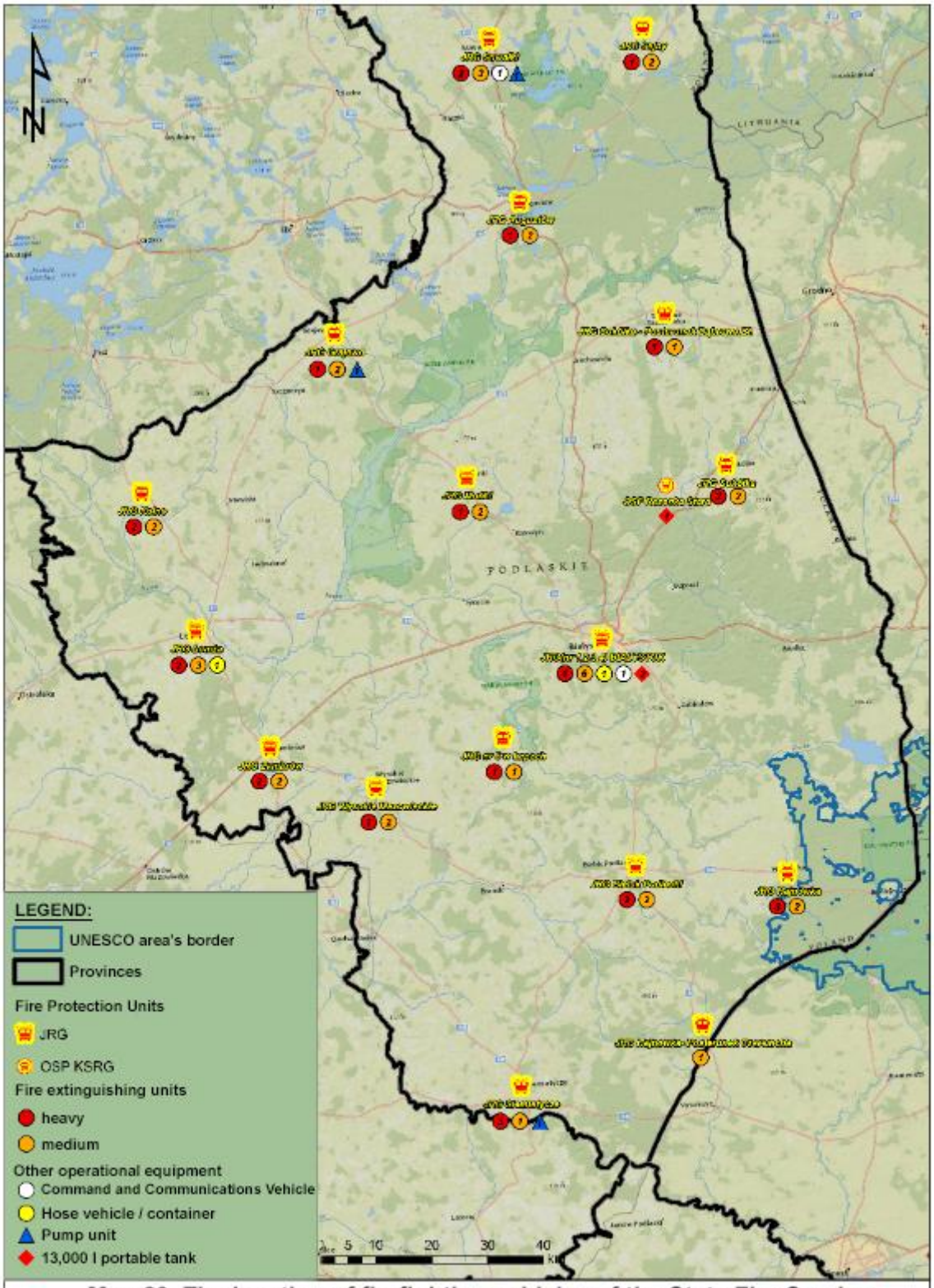
Map 17. Fire sizes at 12% litter moisture and 5m/s wind speed



Map 18. Fire sizes at 20% litter moisture and 2m/s wind speed



Map 19. List of fire protection units and firefighting vehicles



Map 20. The location of firefighting vehicles of the State Fire Service and specialist equipment in the Podlaskie province