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FOREST FUNCTIONS AND ABIOTIC THREATS IN PRIVATE FORESTS: CONCLUSIONS FROM AN EMPIRICAL ANALYSIS OF STAKEHOLDER OPINIONS

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ABSTRACT: The study aimed to recognise the preferences of various stakeholder groups representing three regions of Poland towards the most important forest ecosystem services and to determine the threats to performing these functions resulting from the occurrence of extreme weather phenomena. The study was based on surveys conducted in 2019 among various stakeholders in three regions of Poland. The respondents assigned a point weight value to each of the seven indicated forest functions and reported the occurrence of extreme weather events causing damage to forests owned or supervised by them. The survey results indicate that for all stakeholders, the most important function of the forest is timber production. However, respondents from the southern region paid more attention to water protection through forests than respondents from other regions.

KEYWORDS: public forest functions, timber production, weather phenomena, abiotic damage, social research, stakeholders

Introduction

Regardless of the form of ownership or the method of management, forest ecosystems are suppliers of many products and services, both marketable and with the features of public goods or services (Thorsen & Wunder, 2014; Miura et al., 2015; Biber et al., 2020). Contrary to public forests, private forests' main difference in the supply of public goods or services is the need to take into account obligations to their owners, resulting from their property rights. They are expressed, *inter alia*, by numerous programs compensating forest owners, e.g. the costs of biodiversity protection or lost income due to resignation or limitation in timber harvesting (Engel et al., 2008; Abildtrup et al., 2021). In the light of the search for compromises between timber production and public functions, defined in the literature for over a decade as regulatory or cultural services (Felipe-Lucia et al., 2018), the issue is of particular importance. Hence, it is necessary to know not only the expectations of private forest owners but also the level of their knowledge and environmental awareness, which is shaped by the represented system of values. It determines the manner of implementing forest management, expecting a wide involvement of the private forest sector in activities for the protection of biodiversity, climate, water and soil. Knowledge in the abovementioned field is necessary to implement the best solutions for multifunctional forest management, which consists of the main goals which remain competitive with each other to a varying degree. In addition, the adopted goals, both at the planning stage and their implementation, must be subject to increasing modification, taking into account the intensifying effects of extreme weather phenomena in recent years (Hanewinkel et al., 2013; Spathelf et al., 2014) that threaten the sustainability of forest ecosystems. In Poland, the structure of forest ownership varies regionally (Wysocka-Fijorek, 2014; Gołos et al., 2021). The regions selected for the survey are characterised by forest land in a total country area and a share of private forests that corresponds to the national average (Figure 1). The significant proportion of private forests, particularly in some regions, makes knowledge of the importance of selected forest functions, including timber production functions, in the context of both managing and maintaining the sustainability of private forests increasingly important for representatives of four groups of stakeholders associated with private forests, including forest owners. In this context, it is important to identify which extreme weather events pose the greatest threat to forest sustainability. The aim of the study was to recognise the preferences of various stakeholder groups representing three regions of Poland towards the most important forest ecosystem services and to determine the threats to

performing these functions resulting from the occurrence of extreme weather phenomena.

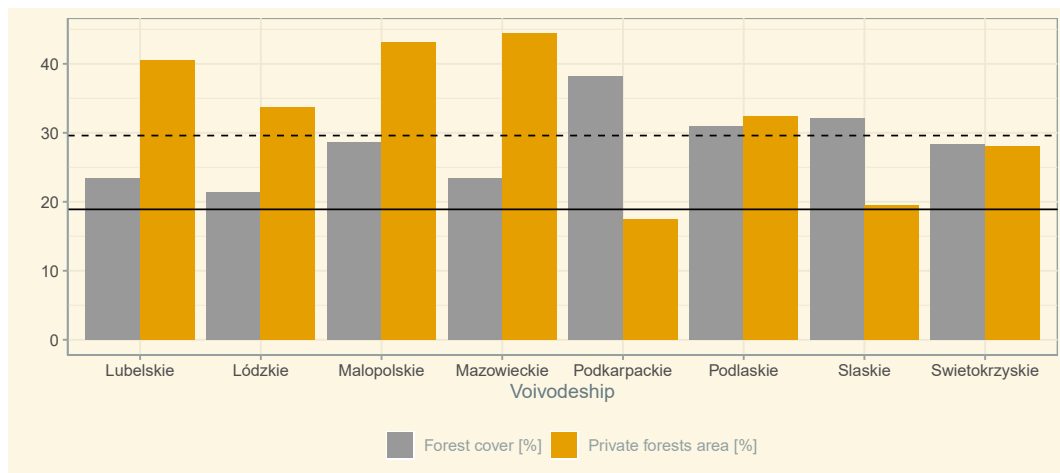


Figure 1. Forest cover (grey bars) and proportion of private forest area (orange bars) in the selected Polish voivodships

The black dashed line denotes the forest cover of Poland, while the solid black line denotes the average proportion of private forest areas in Poland.

Source: authors' work based on <https://bdl.stat.gov.pl/bdl/dane>.

Research methods

The paper presents the survey results, with the application of the questionnaire conducted among participants of training courses organised for stakeholders of private forests. In 2019, as part of the project entitled: Private forests – opportunities, problems, solutions, the training courses took place in eight voivodships, with the highest share of private forest areas in Poland.

The survey questionnaire consisted of two substantive parts and the respondent's record (age, sex and education). The first part of the questionnaire contained seven questions that were completed by all participants of the training. The second part of the questionnaire contained thirteen questions and was completed only by private forest owners participating in the training. The organiser of the training did not limit the number of participants, and participation in the training was voluntary and free of charge.

In the publication, we present the structure of stakeholders' declarative responses to the two questions in the first part of the questionnaire:

- 1) Please assess the importance of the tasks fulfilled by the forest and forest management. Which of the following tasks should be considered to be the most important? – please estimate the value of 100 points at the participation in the abovementioned tasks,
- 2) Have you experienced the effects of the following extreme weather events within the last 5 years? (please indicate by X).

The purpose of the first question was to determine the significance of the issue of the forest functions proposed in the cafeteria-style checklist to the respondents. The correctness of the presentation of the problem (the content of the question), the adopted assessment scale and the selection of categories presented in the cafeteria (assessed forest functions) were verified in the previously conducted research (Gołos, 2018). The task of the respondents was to determine the importance of five protective functions fulfilled by the forest: water, soil, nature, air, and climate protection, and two production forest functions – timber and use for non-timber forest products (e.g. berries, mushrooms). The format of the question allowed the respondents to indicate and evaluate other functions not listed in the cafeteria-style checklist.

In the analysis was assumed that if the respondent did not declare any points for a given function of forest, then such a case was treated as an assessment in which the respondent pointed at 0 points. Due to the results were left-skewed with a high proportion of 0, they were scaled up to obtain a normal distribution. The function that received the highest average value in the respondents' evaluation was used as the transformation benchmark. Scaling was performed according to the following formula:

$$Z_{ik} = Y_{ik} - X_k \quad (1)$$

where: Z_{ik} – rescaled value for the k respondent assessing the i function, Y_{ik} – k respondent's assessment value indicated for the i function, X_k – k respondent's assessment value indicated for the timber harvesting function of the forest. The transformation allowed to obtain a distribution close to normal (median 0, mean value 0, range from -100 to 100).

The mean values of the rescaled ratings for all functions were compared using the multivariate analysis of variance (*aov()* function) according to the next model:

$$Z_{ijn} = X_i + W(X_j) + R(X_j)_r + e_{ijn} \quad (2)$$

where: Z_{ijn} – rescaled ratings for function i in the survey of participant n from group j in region r , X_i – expected value for function i , $W(X_j)$ – effect of the group of respondents j (PFO, LGA, SFNFH, Others) for the expected value of function i , $R(X_j)_r$ – the effect of the studied region r (East, South, Central) for the expected value of the function i , e_{ijn} – the difference between the expected value and the rescaled ratings for the function j in the survey of participant n representing the group j in the region r .

The purpose of the second question was to find out the frequency of forest damage caused by floods, droughts, hailstorms, snow damage, frost and wind damage. The respondents could indicate from among the six questions listed in the cafeteria-style checklist any number of phenomena that occurred in forests.

The weather phenomena indicated by the respondents received a value of 1, and those that were omitted by the respondents, the value of 0. The data obtained in the answers of respondents possessed a Bernoulli distribution. The comparison of the frequency of the occurrence of weather phenomena was carried out using the multivariate logistic regression analysis (*glm()* function using the parameter family = 'binomial') according to the following model:

$$Y_{ijn} = P_i + W(P_i)_j + R(P_i)_r + e_{ijn} \quad (3)$$

where: Y_{ijn} – the presence of the weather phenomenon i according to participant n representing the group of respondents j in the studied region r , P_i – frequency of the weather phenomenon i , $W(P_i)_j$ – correction for the frequency of the weather phenomenon i according to the group of respondents j (PFO, LGA, SFNFH, Others), $R(P_i)_r$ – correction for the frequency of the weather phenomenon i in the studied region r (East, South, Central), e_{ijn} – the difference between the expected value and the presence of the weather phenomenon i according to participant n representing the group of respondents j in the studied region r .

Considering the fact that the training was attended by representatives of various stakeholder groups and the training courses were organised in eight regions of Poland with the highest share of private forests, the results were presented in the following division:

- 1) the four most important groups of private forest stakeholders: forest owners, employees of local government administration (both municipalities and starosts of units exercising statutory supervision over forest management in private forests), employees of the State Forests National Forest Holding, and representatives of other entities, including persons who are not forest owners. The identification of the representatives of the distinguished groups of stakeholders was performed on the basis of the declarations of the respondents, indicated in the first question of the questionnaire, where the role of the respondent participated in the training was declared.
- 2) on the basis of the geographical vicinity of the voivodeship, in which the training courses were organised, there were distinguished three regions of Poland: central (Łódzkie, Mazowieckie, and Świętokrzyskie), southern (Małopolskie and Śląskie), and eastern (Podlaskie, Lubelskie, and Podkarpackie).

The results of the research were supplemented with the social characteristics of the research sample. The structure of gender and education of the respondents and their average age were presented, considering the division into stakeholder groups and regions. Due to the cases of participants who at the same time declared that they were private forest owners and performed specific functions in local government administration units or in the State Forests, it was assumed that in the analysis of the results for three groups of stakeholders, these respondents would not be considered. The analysis of the data of the survey was carried out with the use of the R program for statistical analysis and graphics (R Core Team, 2020).

Results of the research

The questionnaire was completed by 509 participants of training courses – 135 forest owners, 188 representatives of local government administration, 152 foresters representing the State Forests, and 34 people representing other institutions outside the local government and SFNFH. Among all respondents, 178 came from the voivodships included in the central region, 125 belonged to the southern region, and 206 from the eastern region.

The results concerning the answers to the questions about the most important functions fulfilled by forests and the occurrence of extreme weather phenomena were elaborated based on 455 and 469 questionnaires, respectively, due to the lack of a precise answers in other questionnaires. Information from the respondent's record was prepared on the basis of 461 questionnaires.

The best-educated group of stakeholders (the share of respondents with higher education) were employees of the State Forests and local government units, respectively – 83.56 and 82.02% of the respondents. The respondents with higher education among forest owners constituted 58.21%, and among the remaining persons, 48.48% of the respondents (Table 1).

The oldest group of respondents were forest owners and respondents from southern Poland. The average age of all respondents of forest owners group was 53 years, while 51 years was the average age of respondents from southern Poland. Private forest owners were about 10 years older than the remaining respondents (Table 1-2). The respondents from the southern region of Poland were about 5 years older than the respondents from the eastern region and about 8 years older than the participants of the training courses from the center of the country (Table 2).

Among participants of training courses from the central region, 87.13% of persons declared higher education. The smallest share of people who declared higher education were participants from the southern region – 61.67% of the respondents (Table 2).

Table 1. Social characteristics of representatives of four stakeholder groups, defined in 2019 in the survey of participants of training courses during the project: Private forests – opportunities, problems, solutions

Data of the respondents' records	Groups of respondents											
	Private Forest owners (PFO)			Employees of local government administration (LGA)			Employees of State Forests (SFNFH)			Others		
	N	X	SD	N	X	SD	N	X	SD	N	X	SD
Age [years]	126	53.13	11.94	168	43.44	11.25	139	44.35	12,55	28	43,46	14,24
Education	N	%		N	%		N	%		N	%	
Primary	2	1.49		0	0		0	0		2	6.06	
Professional	15	11.19		1	0.56		0	0		7	21.21	
Secondary	39	29.10		31	17.42		24	16.44		8	24.24	
Higher	78	58.21		146	82.02		122	83.56		16	48.48	
Total	134	100.00		178	100.00		146	100.00		33	100.00	
Gender	N	%		N	%		N	%		N	%	
Male	117	87.31		119	67.23		108	72.97		25	75.76	
Female	17	12.69		58	32.77		40	27.03		8	24.24	
Total	134	100.00		177	100.00		148	100.00		33	100.00	

N – number of respondents, X mean value, SD – standard deviation

Source: authors' work.

The males were the main group of the stakeholders. In the group of private forest owners, they constituted 87.31%, while in the group of local government administration employees – 67.23% of the respondents (Table 1). Males constituted the largest part of the respondents from the southern region (84.30%), while their share among participants of training courses in the central region was 63.91% (Table 2).

The timber production function were assessed differently by representatives of four stakeholder groups (Figure 2a). The highest scores were declared by SFNFH employees and forest owners (PFO) – the average was 23.9 ± 1.33 and 22.4 ± 1.44 points, respectively. Government administration employees (LGA) assessed the functions significantly lower compared to the two above-mentioned groups of respondents – the average was 17.3 ± 1.25 points. The fourth group of stakeholders – other participants, assessed the timber production function, as did it SFNFH employees and PFO (no significant differences compared to LGA employees, Figure 2a) – the average was 22.0 ± 2.95 points.

Table 2. Social characteristics of representatives of the three regions of Poland, defined in 2019 in the survey of participants of training courses during the project: Private forests – opportunities, problems, solutions

Data of the respondents' records	Region of Poland								
	Eastern			Central			Southern		
	N	X	SD	N	X	SD	N	X	SD
Age [years]	187	46.13	11.83	165	43.46	12.63	109	51,26	12,90
Education	N	%		N	%		N	%	
Primary	2	1.00		0	0.00		2	1.67	
Professional	7	3.50		4	2.34		12	10.00	
Secondary	52	26.00		18	10.53		32	26.67	
Higher	139	69.50		149	87.13		74	61.67	
Total	200	100.00		171	100.00		120	100.00	
Gender	N	%		N	%		N	%	
Male	159	78.71		108.00	63.91		102.00	84.30	
Female	43	21.29		61.00	36.09		19.00	15.70	
Total	202	100.00		169	100.00		121	100.00	

N – number of respondents, X – mean value, SD – standard deviation

Source: authors' work.

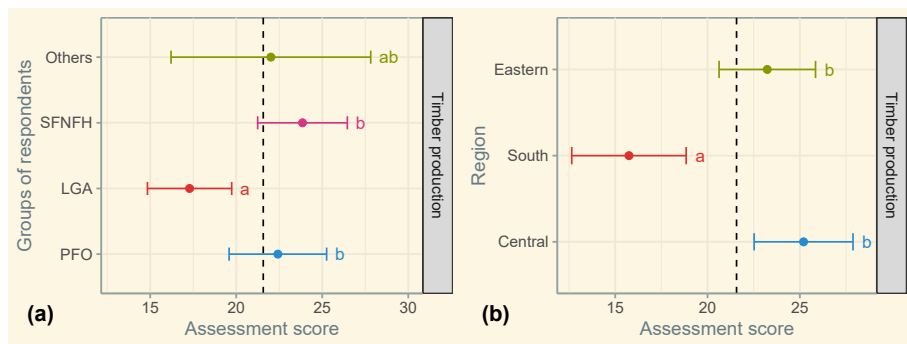


Figure 2. The assessment of the importance of forest functions importance, defined in 2019 in the survey of participants of training courses during the project: Private forests – opportunities, problems, solutions

The results were grouped by respondents (a) and studied region (b), points, and error bars indicate the mean value and 95% confidence interval of the assessment. The black dashed line demonstrates the mean assessment by all respondents for a particular function. The same letters indicate a lack of statistically significant differences ($p < 0.05$).

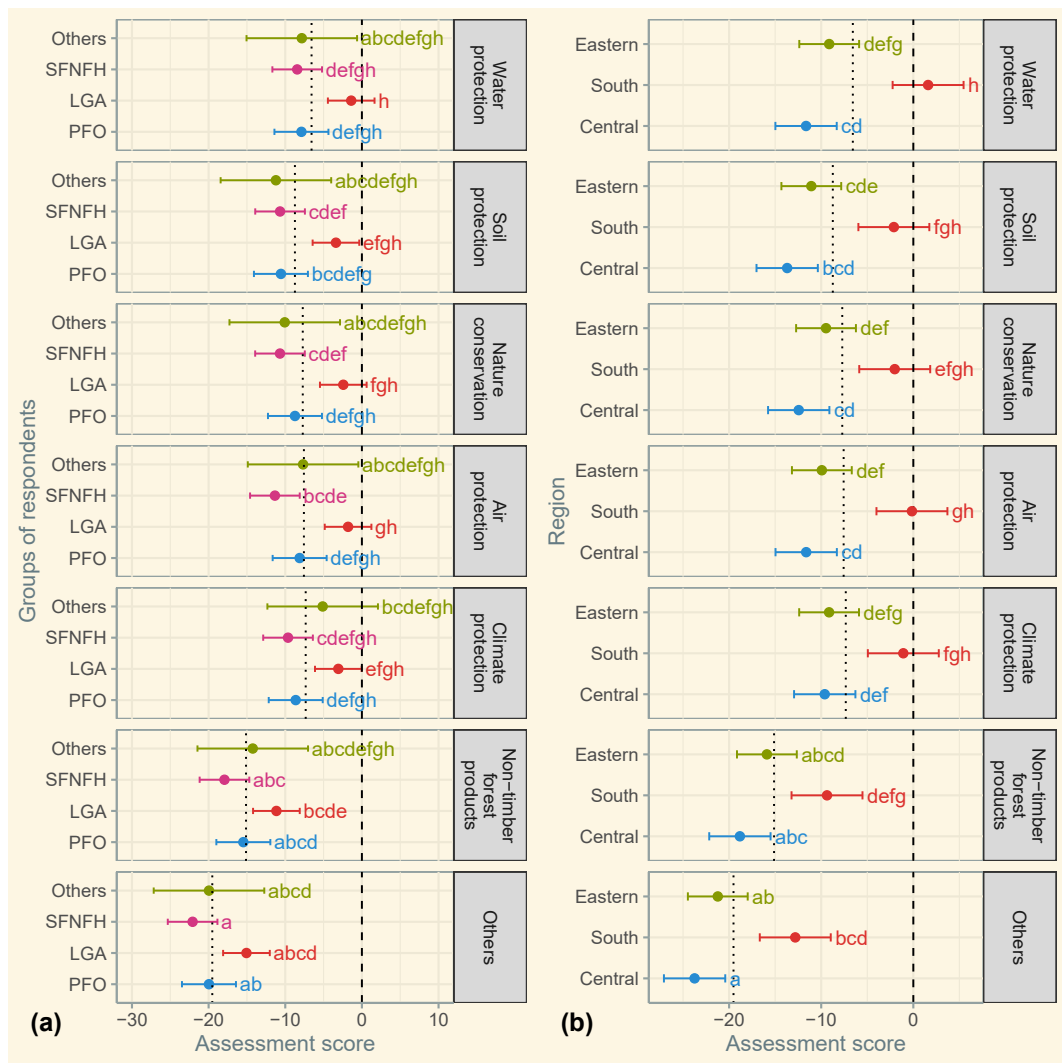


Figure 3. The differences between the importance of studied forest functions and timber production function, defined in 2019 in the survey of participants of training courses during the project: Private forests – opportunities, problems, solutions

The results were grouped by respondents (a) and studied region (b), points, and error bars indicate the mean value and 95% confidence interval of the assessment. The black dotted line demonstrates the mean assessment by all respondents for a particular function, the black dashed line demonstrates the reference line, i.e. assessment of timber production function. The same letters indicate a lack of statistically significant differences ($p < 0.05$).

Source: authors' work.

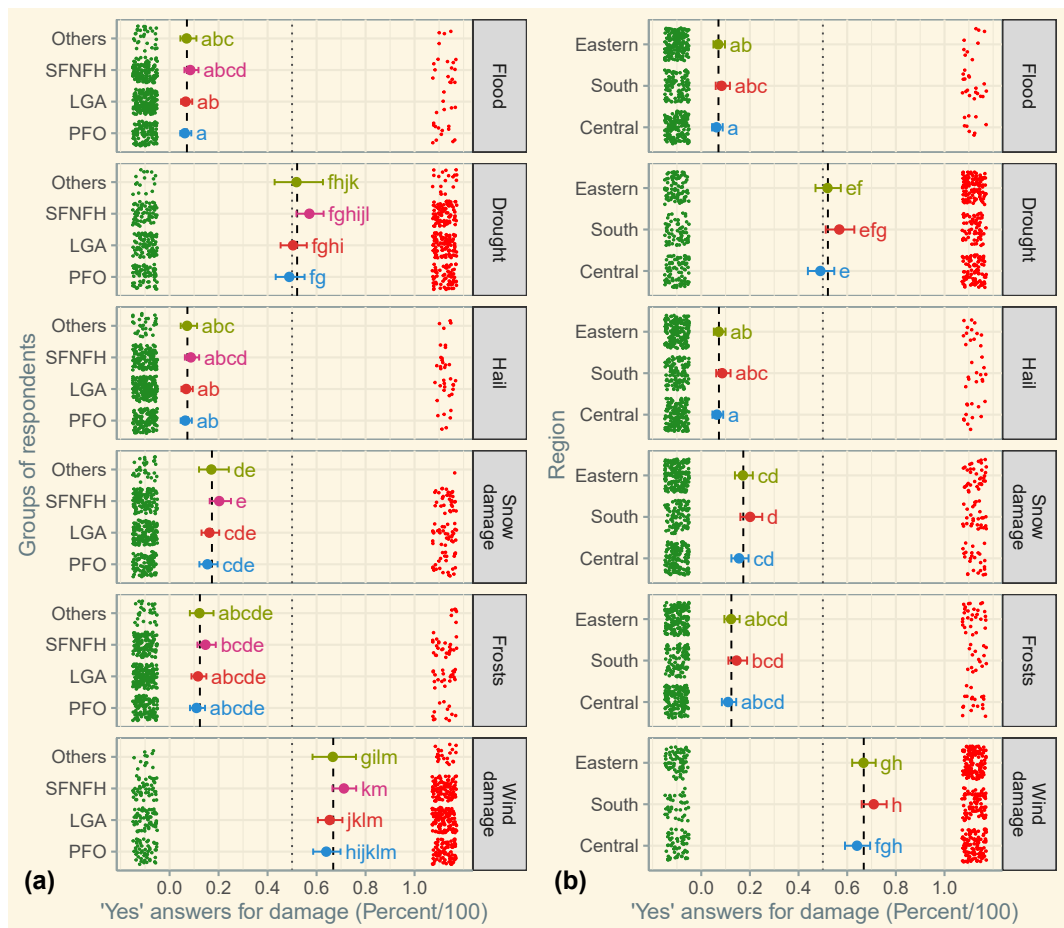


Figure 4. The occurrence of extreme weather phenomena indicated by representatives of four stakeholder groups, defined in 2019 in the survey of participants of training courses during the project: Private forests – opportunities, problems, solutions

The results were grouped by respondents (a) and studied region (b), points indicate the proportion of occurrence of the phenomena for the studied period (2015-2019), and error bars demonstrate a 95% confidence interval for observed proportions. The Grey dotted line indicates the expected proportion for weather phenomena, black dashed line illustrates the observed by respondents' proportion for each weather phenomenon. Green dots below 0 shows the number of respondents that did not observe weather phenomena, while red dots above 1 shows the number of respondents that observed weather phenomena. The same letters indicate a lack of statistically significant differences ($p < 0.05$).

Source: authors' work.

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The comparison of the assessment of the timber production function by regions (Figure 2b) shows that for the inhabitants of the eastern and central parts of the country, the mentioned function is significantly more important (the average was 23.2 ± 1.33 and 25.2 ± 1.36 points, respectively) than for the inhabitants of southern Poland, where the average was 15.7 ± 1.58 points.

Compared to the function of timber production, the remaining functions were assessed much lower (Figure 3); Water protection: -6.57 ± 0.98 , Soil protection: -8.74 ± 0.94 , Nature conservation: -7.72 ± 0.91 , Air protection: -7.57 ± 0.99 , Climate protection: -7.33 ± 0.99 , Non-timber forest products: -5.1 ± 0.80 , Others: -19.5 ± 0.85 . While the differences in the assessment between the abovementioned functions and the timber production function in the case of LGA employees (Figure 3a) and residents of southern Poland were significantly lower than other training participants (Figure 3b).

Wind damage and drought were the most frequently indicated by the respondents among the studied weather hazards. Out of 10 respondents, almost 7 people indicated damage caused by wind, and 5 people reported damage caused by drought (Figure 4). There are no significant differences in the assessment of the value of threats in regions and stakeholder groups, although the factors mentioned above were slightly more often indicated by employees of the SFNFH and respondents from southern Poland. The damage caused by the remaining factors was indicated significantly less frequently than the abovementioned factors. The four other factors, apart from drought and wind damage, were indicated by 1-2 people out of 10 respondents.

Discussion

Despite the small sample size, which does not have the characteristics of a random sample, the obtained results provide, for the first time in Poland, information on the importance of selected forest functions, including the timber production function, for representatives of four stakeholder groups related to private forests, including forest owners. Also, the participants' responses of training courses allowed for determining which extreme weather phenomena pose the greatest threat to forest sustainability. The opinions presented, especially regarding the importance of forest functions, compared with the amount of hypothetical compensations expected by forest owners (Gołos et al., 2021), are a valuable contribution to the discussion of the scale and their consequences. The survey responses also indicate to what kind of extent forest owners are ready to accept the planned restrictions on the use of timber, referred to in such documents as the Biodiversity

Strategy (EU Biodiversity..., 2020), the European Forest Strategy (New EU..., 2021), or the new Strategy European Union on adaptation to climate change (Forging a climate-resilient..., 2021).

The concept of forest functions was used in the questionnaire research because it is more associated with forest management, making it a closer concept for the surveyed stakeholder groups than ecosystem services, understood as benefits that are derived from forests (Maes et al., 2016). Both concepts, i.e. services and functions, despite some differences (Bončina et al., 2019), can be treated as synonyms by stakeholders. On the other hand, the concept of ecosystem services has been dominant in scientific studies and political documents for at least 10 years. This opinion was confirmed by a detailed analysis carried out by Kindler (2016). Its results draw attention to the fact that both concepts have developed similar definitions and classification schemes, as well as used similar valuation methods, although indications of their value of assessment can be various. The advantage of the presented results is the possibility of comparing the structure of the preferences of four groups of stakeholders related to private forests against selected protective functions and two production functions. The results of the survey summarised in the regional system enable the assessment of differences in the indications of respondents from different regions of Poland.

The high value of the assessment of the timber production function, indicated by the representatives of the surveyed stakeholder groups, should not come as a surprise because timber is the most important source of commercial and economic benefits for forest owners. In the case of foresters and starosty employees, the educational profile and professional experience that allowed for a better understanding of the basics of forest management could determine the high assessment of this function.

The revealed preferences of stakeholders, especially forest owners in Poland, are to some extent confirmed by data in Germany (Joa & Schraml, 2020), Finland (Sheremet et al., 2018), and France (Petucco et al., 2015). In the first survey, 69% of German forest owners emphasised the importance of timber in terms of self-sufficiency of construction and firewood needs, while in the second one, 56% of forest owners indicated timber production as the most important goal of their forest holdings. In France, timber production is the most important for only about half of the forest owners. In Poland, there is no research on the typology of interests of forest owners. However, in studies from other countries, forest owners deriving economic gains from owning a forest are referred to as investors (Kuuluvainen et al., 1996; Favada et al., 2009), owners with an economic interest (Bieling, 2004) or looking for a profit (Serbruyns & Luysaert, 2006). Such attitudes are fully understandable if we recall the results of Swedish studies (Bjärstig & Kvastegård, 2016), which show that undertaking initiatives in the field of nature protection and

perceiving the social functions of the forest are depended on the economic effects of a forest holding. An indirect confirmation of this approach among Polish forest owners is the average monetary value indicated as Willingness to Accept (WTA) for four different levels of limitations in timber harvesting (Gołos et al., 2021).

Despite the fact that respondents paid special attention to the function of producing timber raw material, it is also noteworthy that the obtained results at a high level draw the preferences of participants in the survey for public functions such as protection/regulatory services, which do not constitute a source of personal benefits. This type of attitude revealed among private forest owners in Poland, related to the perception of the environmental functions of forests, is confirmed by research from the USA and Europe (Wiersum et al., 2005; Schenk et al., 2007; Veenman et al., 2009, Nordlund & Westin 2010; Sourdril et al., 2012; Sorice et al., 2014; Stanislovaitis et al., 2015; Joa & Schraml 2020). Forest owners or, more broadly, representatives of various stakeholder groups related to private forests, whose value system takes into account, apart from economic and/or business aspects, public benefits, are referred to as forest ecologists (Pregernig, 2001) or idealists (Selter et al., 2009). It seems that the widespread acceptance of such an understanding of the public needs of forests, especially by those stakeholder groups that achieve economic benefits from the use of wood, will become prevalent only under such conditions when there will be a partial transfer of economic benefits related to the supply of public functions. Public institutions can play a large role in this respect, using legal regulations and the authority assigned to them which can effectively engage private entities in the implementation of forest policy objectives (Weiss et al., 2011; Abildtrup et al., 2021). This function, in turn, must encourage the provision of public services (regulatory and social) that support the adaptation of forests to climate change or the protection of biodiversity (Mayer, 2019) and thus contribute to the maintenance and improvement of the standard of living. The contribution of forest owners in this function of forests may facilitate the implementation of the objectives of planning and protection of forest areas on the landscape scale in the conditions of fragmentation of private forest property that exists in Europe, including Poland. Activating the process of networking of private forest owners is one of the solutions that can help in this field, and which is still waiting for financial support in many European countries. Creating organised forms of cooperation between members of forest owners (forest associations, cooperatives, or forest chambers) could increase their level of knowledge and awareness. The additional value for forest owners managing their forests as part of organised forms of activity could also be measurable economic benefits, including reducing the costs of forest management and

increasing its effectiveness through the joint organisation of farm work or the sale of timber (Górriz-Mifsud et al., 2019).

In order to evaluate the obtained results of the valorisation of forest functions, reference analysis was performed to the results of research in various forest facilities among users of recreational goods and services of the forest functions conducted on various samples, including nationwide ones. Table 3 presents the comparison of the average value, established on the basis of nine other studies (Gołos 2018), with the average value obtained in the studies of this work.

Table 3. Comparison of social preferences regarding selected forest functions established on the basis of surveys among tourists and four groups of private forest stakeholders

Forest functions	Average score based on surveys among private forest stakeholders	Average number of points based on 9 surveys among tourists*
Water protection	15,71	11,77
Soil protection	13,48	9,33
Nature conservation	14,42	22,61
Timber production	23,48	7,70
Air protection	14,82	24,14
Climate protection	16,01	12,24
Non-timber forest products	8,60	8,67
Others	10,22	0,28

* In the set of evaluated functions of the forest also, the recreational function was included, which was not assessed in the presented results of the questionnaire surveys in this paper.

Source: authors' work based on (Gołos, 2018).

The comparison of the obtained results shows a significant difference in the assessment of the timber production function of the forest, indicating the importance of the context and conditions in which the social questionnaire survey was carried out. Thus, the subjectivity of the assessment of the value of the timber production function is more important for private forest stakeholders than for those visiting the forests for recreational purposes. Forest-related stakeholders also rated higher those functions that directly determine the productivity of forest areas and can prevent losses. The first of these groups of functions includes the function of water and soil protection (fertility and humidity of the habitat), while the second one is the function of climate protection and minimisation of economic losses caused by catastrophic

weather phenomena. At the same time, for the forest stakeholders, functions such as nature or air protection were of less importance. They were combined with the creation of favourable conditions for rest, tourism, and recreation in forest areas. An interesting result is a very similar assessment of the importance of the supply function of forest use for non-timber forest products, such as berries, mushrooms, and herbs, by both groups – forest stakeholders and tourists.

Our studies revealed that the inhabitants of mountain areas have different preferences regarding the functions of the forest and pay more attention to the protective functions of the forest than the other respondents. It is not a unique situation. Häyhä et al., (2015) noted that due to the presence of human settlements in forested mountain areas, the hydrogeological protection service in areas with a high risk of avalanches and landslides was most important, accounting for 40% of the total economic value, while timber products were accounted for 28%. In their studies conducted in alpine forests, a total of about 60% of the economic value was not reflected in market transactions.

An attempt to determine the frequency of occurrence of threats from abiotic factors that owners and managers of private forests encountered in the last 5 years showed interesting research results. Obviously, regardless of the stakeholder group, the results indicate that droughts and winds are the greatest threats to forests. While, in the regional indications, despite slight differences, the structure of responses reliably reflects the different natural conditions of Poland (the southern region is mountainous, and the remaining regions – are lowland), which determines the frequency of occurrence of abiotic damage. Especially, such differences are evident in the case of wind and snow damage and drought.

Conclusions

The most important forests function for forest stakeholders in the production of timber. Particularly, foresters pay attention to this function. Contrary, the production of timber was of the least importance for the employees of local government administration units. In the regional system, the function of timber production was the most important for respondents from the region of central Poland (Łódzkie, Mazowieckie and Świętokrzyskie voivodships).

The forest owners are interested in timber production, however, they also indicated the importance of protective functions. One of the ways of changing the expressed opinions into real behaviour may be a system of incentives, including financial ones, which would be a source of compensa-

tion for forest owners in situations where the intensification of public functions leads to loss of revenues and/or generates higher costs of forest management.

The respondents most often indicated hurricane winds and drought among the effects of six extreme weather phenomena that threaten forest management. There were no clear differences in the indications of the distinguished groups of stakeholders. The analysis by regions showed that droughts were the least significant in the south of Poland, while wind damage in the eastern part (Podlaskie, Lubelskie and Podkarpackie voivodships) and southern (Małopolskie and Śląskie voivodships). The respondents from the south of Poland more often indicated snow damage and floods as threats.

Stakeholders whose forests are exposed to a greater intensity of unfavourable abiotic factors, pay more attention to the protective functions of forests than those whose unfavourable abiotic factors do not have as great an influence on forest management.

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The contribution of the authors

Conception – Emilia Wysocka-Fijorek, Piotr Gołos.

Literature review – Emilia Wysocka-Fijorek, Piotr Gołos.

Acquisition of data – Piotr Gołos, Emilia Wysocka-Fijorek, Wojciech Gil, Małgorzata Sułkowska.

Analysis and interpretation of data – Emilia Wysocka-Fijorek, Piotr Gołos, Vasyl Mohytych, Wojciech Gil, Małgorzata Sułkowska.

Total: Emilia Wysocka-Fijorek (30%), Piotr Gołos (25%), Wojciech Gil (15%), Małgorzata Sułkowska (15%), Vasyl Mohytych (15%).

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