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Perspectives on protected area and wildfire management in the Black Sea region

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Abstract Protected areas are necessary for the conservation and enhancement of biodiversity. Wildfires are major threats to forests and other natural areas, because they may cause irreversible damages. The aim of this study was to analyze the perspective of experts (N = 284), from six countries of the Black Sea, on the current status and problems of protected areas and wildfires. Understanding their points of view could enhance future management on these issues in the region. Data collection was carried out for 9 months, using a web-based questionnaire. Wildfires were perceived as a serious problem in Turkey, Armenia and Greece but as a substantially less serious problem in

Romania, Ukraine and Moldova. In Greece, Armenia, and especially Ukraine, the current designated protected areas are considered sufficient to maintain biodiversity, while in Romania, Turkey, and especially Moldova, more areas should be designated as protected. A major need in all countries (except for Turkey) is the increased use of information and communication technologies for both wildfire suppression and protected area management. Experts were divided on whether wildfire suppression and management of protected areas are interconnected. However, there is growing awareness of the adverse impacts of climate change in protected areas and the frequency of wildfires in the future. The most frequently suggested measures to alleviate these impacts were: changes in forest management and increasing public awareness for wildfire suppression, along with changes in forest management and increased staff training to enhance protected area conservation.

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Introduction

Protected areas are essential because they help sustain life on earth by conserving different types of landscapes that are rich in biodiversity while also providing many benefits to humans (Worboys and Winkler 2006; Figueroa and Sánchez-Cordero 2008). Worldwide, the establishment of protected areas, which cover 12% of the earth's terrestrial surface (IUCN 2005), was the greatest land-use transformations of the 20th century (Worboys and Winkler 2006). In the European Union (EU), the ecological network, Natura 2000, has been established to stop the decline in biodiversity (European Commission 2015a). The Natura 2000 Network is based on the Habitats Directive (European Council 2009) and currently protects around 18% of the land in the EU countries.

In the past, there was a common misconception that protection of natural areas, especially forested ones, presupposed the elimination of wildfires. The reason for this belief was because people wanted to minimize or eliminate negative environmental, economic, and social impacts caused by wildfires (Kalabokidis et al. 2002). The prevention of any type of wildfire in these areas, along with minimal management, increased the amount of forest fuels that led to major catastrophic fires (Odion et al. 2014). Instead, fuel suppression policies and management, such as fuel treatments, can help mitigate wildfires in all forested areas of the Mediterranean (Xanthopoulos et al. 2006; Fernandes et al. 2014; Salis et al. 2016; Curt and Frejaville 2018).

Wildfires are a natural part of many ecosystems and maintain the integrity and species composition (Odion et al. 2014). This is the reason why a sustainable coexistence with wildfires is required by adopting integrated fire management plans that allow wildfires to operate as a natural ecosystem process (Silva et al. 2010; Moreira et al. 2011; Moritz et al. 2014). These plans must address the role of even large wildfires, since they play an important role in ecosystems dynamics and help maintain the health of fire-dominated ecosystems (Zaimes et al. 2015). Wildfires in the Mediterranean appear to be decreasing (San-Miguel-Ayanz et al. 2016; Turco et al. 2016) but the weather conditions appear to becoming more conducive to wildfires, so the danger of wildfires still remains (European Environment Agency 2017a, b).

These conducive weather conditions are directly connected to climate change. The Intergovernmental Panel on Climate Change (IPCC 2014) has forecasted an increase in temperatures that should lead to higher evapotranspiration rates and an atmosphere holding higher percentages of water vapor. The precipitation intensity is expected to increase even in areas where the total precipitation is

expected to decrease. More intense precipitation and floods for short periods of time, along with longer periods with little to no precipitation, will lead to greater droughts (Pausas 2004; Giannakopoulos et al. 2009). These changes will impact both wildfire risk (Giannakopoulos et al. 2009; Lung et al. 2013; Cardil et al. 2014; Sarris et al. 2014; Venäläinen et al. 2014) and ecosystems resiliencies (Lindner et al. 2010; Seidl et al. 2014; Khaine and Woo 2015).

The natural forested areas of the Black Sea region are limited and degraded since anthropogenic activities have heavily impacted them for centuries (Zaimes et al. 2014). While some of the Black Sea region countries have not had many wildfires in the past, an acceleration is expected because of the increase in temperatures and droughts due to climate change along with geopolitical and economic changes in the early 1990s (Zibtsev et al. 2013). The rural population has decreased as have lands under proper agriculture and forest management, leading to increased abandoned areas. Newly favourable conditions for large wildfires (Zibtsev et al. 2013), along with the ecosystems of the region such as the Caucasus Mountain, the Black Sea Riviera, the Danube River and its Delta, the Rhodope Mountain, and the Evros River indicate the need to suppress excessive wildfires. In many of these ecosystems, transboundary joint regional-scale efforts are required to reduce the negative impact of wildfires and enhance their conservation.

The purpose of this study was to analyze the perspectives of experts in the Black Sea region on: (1) wildfire and protected areas management, (2) climate-change impacts on their management, and (3) the preparedness of the responsible organization and agencies to face current and future problems. New emerging conditions due to climate change make it a priority to understand if the responsible organizations and agencies are prepared and anticipating climate-change implications on wildfires and protected areas. This is the first study, to our knowledge, that focuses on the Black Sea region and includes participants from many different countries of the region.

Materials and methods

Selection of participants and data collection

The chosen participants were either employees from agencies and organizations or stakeholders that work or are interested in wildfire suppression and the management of the protected areas. In more detail, the targeted groups were employees of fire departments, emergency offices, foresters, conservationists, fire experts, natural resource experts, and biologists. The participants were from six

Black Sea countries; specifically, Armenia, Greece, Moldova, Romania, Turkey and Ukraine (Fig. 1). While these countries are in the same region, they differ in geographical (e.g. size, population) and environmental aspects (e.g. forest coverage), and their vulnerability to wildfires and designation of protected areas (Table 1). Having participants from six Black Countries allowed perspectives from around the Black Sea region to be recorded, analysed, and compared to help develop sustainable recommendations for the improvement of these sectors in the region. In environmental planning, experts and stakeholder participation is necessary for acceptable and viable solutions (Bruña-García and Marey-Pérez 2014).

The study was carried out with the help of a web-based questionnaire. The use of web-based questionnaires has increased over the last decades due to their well-documented advantages, especially compared to the postal questionnaire method (Bech and Kristensen 2009). However, special care should be given to the reliability and validity of the obtained data (Best et al. 2001; Fox et al. 2003). Once these problems are resolved, web-based questionnaires can be a reliable, fast, and cost-effective method for data collection (van Gelder et al. 2010). These important preconditions were implemented in this study with the following activities: (1) a list of experts with the appropriate background in every country was initially completed. (2) The included experts in these lists were asked to suggest other possible participants for the study, on the grounds of their qualifications and experience on the questionnaire issues. This “snowball” or chain-referral sampling process (Biernacki and Waldorf 1981) is considered to give the most representative results where the personal experience of the respondents is crucial (Babbie

2010; Tsioras 2012). (3) Then, an email invitation was sent to all potential respondents. (4) A precondition for participation was registration on the questionnaire website, in an effort to ensure that access to the questionnaire would be granted solely to the experts belonging to the lists. (5) All respondents were sent a second email, thanking them for their participation, on which the “send receipt to the sender” option had been enabled. Only questionnaires accompanied by such a receipt were considered for further analysis. These previous steps ensured that all respondents fulfilled the necessary requirements.

The questionnaire was initially designed based on the available literature and discussions with land managers, experts and academics from the countries of interest. The questionnaire was pre-tested with five experts from each country to check for biased, misleading, or confusing questions and to verify the quality and comprehensiveness of the retrieved information.

The web-based questionnaire consisted of four parts and is included in Appendix A as supplemental material. In its first part, survey participants were asked to provide profile information such as their nationality, gender, age, years of experience in wildfire suppression and/or protected areas. The second and third parts focused on the participants' opinions on specific issues regarding (1) wildfire suppression and (2) management issues of protected areas in their countries, respectively. At the end of the second and third parts of the questionnaire, the survey participants were asked to describe in their own words, management actions and other activities that they considered as important for wildfires suppression and the management of protected areas, respectively.

Fig. 1 The survey participants were from six countries of the Black Sea region

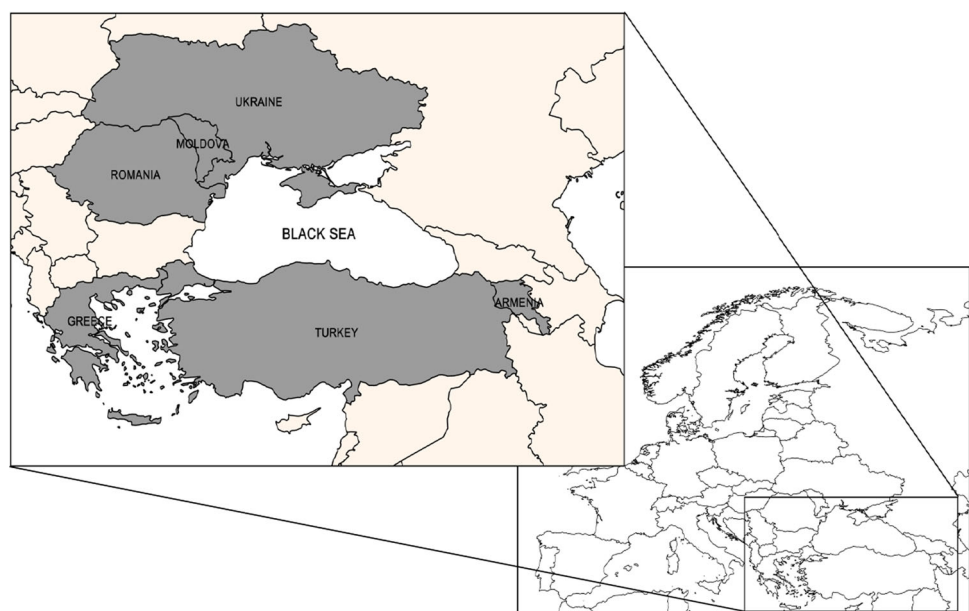


Table 1 Main characteristics of protected areas and wildfires attributes and characteristics of the countries under investigation (baseline for all data is 2015 unless otherwise noted)

Country	Population (Million)	Area (km ²)	GDP (Billion \$)	Forested area (km ²)	Protected areas (#)	Total area of protected areas (km ²)	Protected areas versus country total area (%)	Wildfires per year (#)	Burnt forested area per year (km ²)	Annual forested area burnt versus forested area (%)	Annual budget for fire extinction (Million \$/year)	Number of firefighters (#)
Armenia	3.01	29,743	10.53	3300	266	3871	12.99	63	2.4	0.07	2.06	60
Greece	10.82	131,957	194.9	47,700	551	5500	4.17	13,131	479.91	1.011	53.08	7500
Moldova	3.56	33,846	6.51	4000	312	1894	5.6	28	1.6	0.04	0.007	270
Romania	19.87	238,390	177.5	64,600	574	47,678	20	2451	14.7	> 0.01 ^a	N/A	27,844
Turkey	78.7	783,562	859.4	217,000	1815	56,476	7.21	37,552	161.12	0.072	15.07	12,959
Ukraine	42.93	603,628	91.03	97,100	5693	28,000	4.64	10,413	1063	> 0.01 ^b	3.36	11,179

^aAverage values for the period 2005–2014

^bData from 2010

The binomial questions included in the second and third parts of the questionnaire were used to build a cumulative index for each case. We attributed one point to all answers indicating a problematic issue (e.g. a negative answer to the question “Are the governmental agencies well equipped to manage effectively protected areas?”); otherwise the answers were attributed zero points. The cumulative index was structured by adding the points of each study participant’s answers. Therefore, the first index is hereafter referred to as “Wildfires index” and the second one as “Protected areas index”, respectively. Due to their structure, they both received values within the range of 0–6 points.

The questionnaire was concluded with the fourth part, consisting of three binomial questions. The first question examined the existence of an interconnection between wildfire occurrence and the management of protected areas. Finally, the second and third questions asked the participants about their perspectives on the potential negative impacts of climate change in the future on the management of protected areas and wildfires.

The large majority of the questions were of the closed, binomial (yes/no) type because of the language barriers. In some of the countries (Armenia, Moldova, Romania and Ukraine), where the comprehension of English is limited, the web-based questionnaire was translated in the respective native language in order to increase participation. The use of binomial questions entails a lower level of detail but in our case, it did not threaten the validity of responses. On the contrary, the use of Likert scales or qualitative research would result in larger amounts of collected information, however it was not preferred because of the risk of inadequate results, as a result of the different cultural background of the participating countries (Wagner et al. 2014).

The questionnaire was posted on the suppressfires.eu website for approximately 9 months (March 2014–November 2014). The snowball sampling process resulted in the inclusion of 802 experts on our lists as potential respondents. Some of them were also invited and participated in various Neighborhood Network meetings that were held as an activity for the project “Utilizing Stream Waters in the Suppression of Forest Fires with the Help of New Technologies” funded by EU Black Sea Cooperation Programme.

Statistical analysis

The data were analysed with IBM SPSS Statistics 21.0 software. The analysis was done to understand the perspectives of each country or age group on wildfire suppression and the management of protected areas. A maximum likelihood χ^2 test ($p \leq 0.05$) was also used to find statistically significant differences. In addition, the

Table 2 The socio-demographic characteristics of the survey participants

	Respondents (#)	Percentage (%)
Country		
Armenia	20	7.0
Greece	52	18.3
Moldova	43	15.1
Romania	61	21.5
Turkey	54	19.0
Ukraine	54	19.0
Gender		
Male	218	77.6
Female	63	22.4
Age		
18–25	14	5.1
26–35	85	30.7
36–45	112	40.4
46–55	50	18.1
56–65	15	5.4
> 65	1	0.4

answers of the open-ended questions were encoded and, when possible, grouped into different categories to facilitate the statistical analysis that followed. Categorical principal components analysis (CATPCA) was used to identify consistencies between categories of variables based on the study participants' responses. This analysis was performed with the help of the SPSS categories module. CATPCA is a generalization of principal components analysis (PCA), which reduces the variables in a dataset to a small number of principal components that represents the information in the variables as closely as possible (Tsioras 2012). This optimal quantification of the

categorical modalities of each variable can be obtained through an iterative Alternating Least Squares (ALS) model (Young et al. 1978). The ability of CATPCA to simultaneously handle variables of different analysis levels (nominal, ordinal, and numerical) and to deal with non-linear relationships between variables has resulted in its use as an exploratory technique in many empirical surveys (Gifi 1990; Linting et al. 2007).

Results

A total of 284 questionnaires was completed, with most participants being male (77.6%) (Table 2). Of the respondents, 47.9% had previous experience on wildfire suppression, 36.2% on the management of protected areas, and 20.1% of them on both. The distribution of their experience per years and scientific field is described in Table 3 (χ^2 statistic = 64, $df = 5$, $p < 0.0001$).

Wildfires

The majority (64.4%) of the survey participants regarded wildfires as a serious problem for their country. However, an analysis by country revealed a different situation (χ^2 statistic = 107.941, $df = 5$, $p < 0.0001$) (Fig. S1 in supplemental material). In Armenia, Greece, and Turkey, there is an almost unanimous opinion that wildfires are a serious problem with percentages greater than 94%. In contrast, in Romania, Moldova, and Ukraine, wildfires are still considered a serious problem but by a smaller percentage of respondents (35.7–45.9%). In almost all countries (except Turkey), participant satisfaction regarding existing personnel is higher compared to the equipment used and the implementation of information and communication

Table 3 The management experience of the survey participants (multiple answers were allowed—all percentages were calculated on the basis of number of participants)

Management experience	Country						Total
	Armenia	Greece	Moldova	Romania	Turkey	Ukraine	
Wildfires							
Frequency (#)	8	32	10	39	13	45	147
Percentage (%)	40.0	61.5	23.3	69.3	24.1	83.3	51.7
Protected areas							
Frequency (#)	15	30	10	19	30	3	107
Percentage (%)	75.0	57.7	23.3	31.1	55.6	5.6	37.7
Other environmental							
Frequency (#)	3	10	25	18	22	9	87
Percentage (%)	15.0	19.2	58.1	29.5	40.7	16.6	30.6
Total							
Participants (#)	20	52	43	61	54	54	284
Responses (#)	26	72	45	76	65	57	341

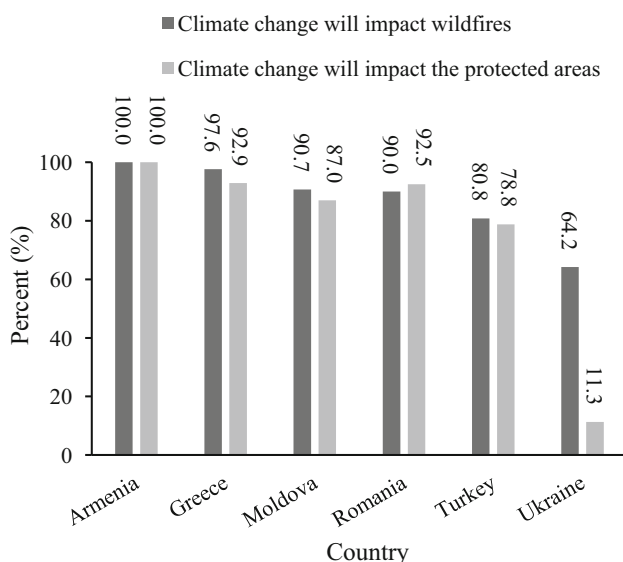
Table 4 Satisfaction of the survey participants for the current number of personnel, equipment, and implementation of information and communication technologies (ICT) in regard to wildfire suppression and protected area management in the countries under investigation

	Wildfire suppression			Management of Protected Areas		
	Personnel (%)	Equipment (%)	ICT (%)	Personnel (%)	Equipment (%)	ICT (%)
Armenia	50	5	5	45	0	0
Greece	53.8	38.5	21.2	9.8	10	13.7
Moldova	39.5	26.2	33.3	21.4	14.3	37.5
Romania	58.3	52.5	49.2	29.6	27.8	23.1
Turkey	68.8	61.1	70.6	37.7	35.8	55.8
Ukraine	100	79.6	3.7	96.3	67.9	3.7
Black Sea region	63.9	49.4	49.4	40.5	29.8	24.2

technologies (ICT) (Table 4). In the case of Ukraine, existing personnel and equipment are considered to be at a very high level, whereas the use of ICT is practically non-existent. In respect to ICT, only participants in Turkey and Romania answered that they are adequately used.

Protected areas

The current designation of protected areas in most countries fulfills the biodiversity conservation target to differing extents (χ^2 statistic = 113.252, $df = 5$, $p < 0.0001$) (Fig. S2 in supplemental material). Ukrainian respondents seemed to be completely satisfied with the areas designated as protected to sustain biodiversity (100%) while respondents from Greece (75.0%) and Armenia (70.0%) also seem to be very satisfied.

**Fig. 2** Expected impacts of climate change on wildfires and protected areas based on survey participant responses

In contrast, participants, especially from Moldova (9.3%) and to a lesser degree from Romania and Turkey (51.8 and 49.1%, respectively), suggest that there is a need for more protected areas in their countries. Current personnel and equipment do not seem to be able to fulfill the needs (less than 50%) for the effective management of the protected areas in almost all countries, except in Ukraine (Table 4). The greatest need in the region appears to be the implementation and use of ICT as the average satisfaction rate was only 24.2%. This is not the case in Turkey, where the satisfaction rate is considerably higher than all the other countries (55.8%).

Interactions between protected areas and wildfires

In our survey, the participants' opinions were divided (χ^2 statistic = 80.921, $df = 5$, $p < 0.0001$) over whether wildfires and management of protected areas are interconnected (Fig. S3 in supplemental material). Participants from the countries that considered wildfires a serious problem (Armenia, Turkey, and Greece) had a greater awareness of this interconnection (65.4–90.0%) compared to those from Moldova, Romania, and Ukraine (5.6–51.2%).

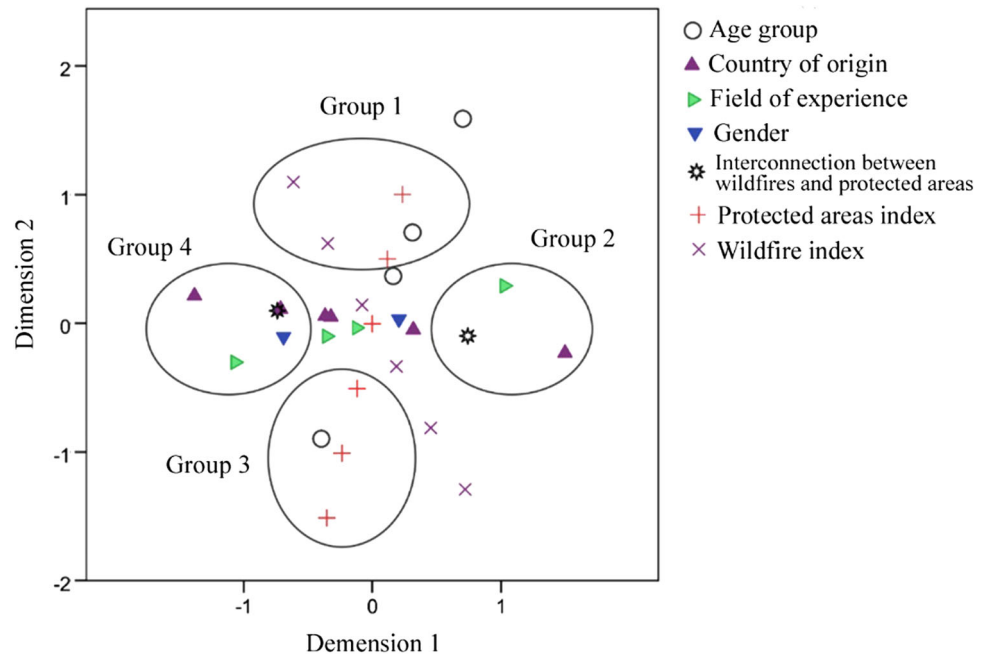
Climate change

The participants believed that ongoing climate change impacts will increase, but to a different extent, for wildfires (85% positive answers of all participants; χ^2 statistic = 132.885, $df = 5$, $p < 0.0001$) and for protected areas (74% positive answers of all participants; χ^2 statistic = 31.674, $df = 5$, $p < 0.0001$). In all countries except Ukraine, participants expected the negative impacts from climate change to increase on both issues according to the large majority of respondents (79–100%) (Fig. 2).

Table 5 The component loadings of the variables used in the categorical principal components analysis (CatPCA)

Variable	Dimension	
	1	2
Country of origin	0.849	- 0.131
Gender	0.372	0.057
Age group	0.299	0.676
Field of experience	- 0.759	- 0.215
Interconnection between wildfires and protected areas	0.731	- 0.097
Wildfire index	- 0.395	0.707
Protected areas index	- 0.132	- 0.565

Fig. 3 The joint plot of the variable categories used in the Categorical principal components analysis (CatPCA)



Categorical principal components analysis (CatPCA)

Seven variables were used in total for the application of the CatPCA method; one of these was measured on the ordinal scale, four on the nominal scale, and two on the numeric scale. The variables used were the following: age group (ordinal, 1–5), country of origin (nominal 1–6), field of experience (nominal 1–4), gender (nominal, 1–2), interconnection between wildfires and protected areas (nominal, 1–2), protected areas index (numeric, 0–6), and wildfires index (numeric, 0–6). The convergence criterion value of 0.00001 was met after 19 iterations.

The two-dimensional solution resulted in eigenvalues of $\lambda_1 = 2.232$ and $\lambda_2 = 1.352$ for the first (PC1) and second principal component (PC2), respectively. Each of these eigenvalues exceeded the acceptance value of 1 (Meulman and Heiser 2001). This combined with the fact that 84.1%

of the total variance can be explained in relation to PC1 and PC2 respectively, suggested the use of a two-dimensional analysis for this dataset.

The values of the variable loadings for the two principle components are described in Table 5. The variables country of origin and interconnection between wildfires and protected areas present very high positive loadings in relation to PC1 and form a group that could be interpreted as local conditions. Similarly, the variables wildfire index and age group form a second group due to their high loadings in relation to PC2 and form a group that could be interpreted as respondents' experience. On the contrary, the highest negative loadings in relation to PC1 and PC2 belong to field of experience and protected areas index, respectively.

The CATPCA program provides scores to variable categories, based on which a dispersion diagram is created. Coordinates for variable categories along each dimension

Table 6 The most frequent survey participants' opinions per country of origin on measures aiming to improve wildfire suppression and the conservation of protected areas

Country	Measures to improve wildfire suppression	Percentage	Measures to improve protected areas conservation	Percentage
Armenia	Replacement of old equipment	55.0	Staff training	35.0
	Forest management	25.0	Forest management	25.0
	ICT implementation	25.0	Legislative changes	10.0
	Staff training	25.0		
Greece	Forest management	38.5	Staff training	23.1
	Increasing public awareness	9.6	Forest management	15.4
	Staff training	7.7	Increasing public awareness	9.6
Moldova	Forest management	25.6	Forest management	18.6
	Better monitoring	11.6	Increasing protection	9.3
	Increasing public awareness	11.6	Better monitoring	9.3
Romania	Forest management	41.0	Legislative changes	16.4
	Replacement of old equipment	21.3	Forest management	16.4
	ICT implementation	13.1	Restriction of harmful economic activities	11.5
	Increasing public awareness	13.1		
Turkey	Increasing public awareness	24.1	Increasing public awareness	9.3
	Forest management	18.5	Forest management	7.4
	Better monitoring	9.3	Increasing protection	7.4
Ukraine	Replacement of old equipment	3.7	Forest management	1.9
	Better monitoring	1.9	Better monitoring	1.9
Black Sea	Forest management	25.4	Forest management	12.7
	Increasing public awareness	12.3	Staff training	10.9
	Replacement of old equipment	11.3	Legislative changes	7.7
	Better monitoring	6.7	Increasing protection	6.7
	Staff training	6.0	Increasing public awareness	6.0

are shown in Fig. 3. Certain variable categories are consistent. With regard to the first dimension, there is consistency (value of the variable categories above 0.5 or below -0.5 in both dimensions) between the following categories: age groups: 46–55 and 56–65, protected area index: 1 and 2, and wildfire index: 5 and 6 (Group 1). Group 2 consists of the categories country of origin: Ukraine, field of expertise: fire, and interconnection between wildfires and management of protected areas: No. Group 3 consists of the categories ages group: 18–25 and 26–35 and wildfire index: 4, 5, and 6. Finally, a last group is formed by the categories country of origin: Armenia and Greece, sex: female, and field of expertise: protected areas (Group 4).

Mitigation measures

Different mitigation measures were suggested by the survey participants for these two issues (Table 6). Changes in forest management came first, in both cases, with 25.4%

for wildfire suppression and 12.7% for the conservation of protected areas.

For wildfire suppression, in three of the countries (Greece, Moldova, and Romania), the participants overwhelmingly believed that changes in forest management is the most important measure to enhance wildfire suppression. In Armenia and Ukraine, the survey participants believed that the most important measure to suppress wildfires more effectively was the replacement of old equipment. This was also considered important in Romania. Finally, in many Black Sea countries (Greece, Moldova, Romania, and Turkey) increased public awareness was an important measure. In Turkey, this was considered as the most important measure.

To improve the management of their protected areas, Turkish survey participants said that the most important measure again was increasing public awareness. This was also important for Greek participants. In Moldova and Ukraine, changes in forest management were considered the most important measure and the second most important for the rest of the countries. Better staff training (Armenia

and Greece), legislative changes (Romania and Armenia), more effective enforcement and stricter restrictions and penalties (Romania), better monitoring (Moldova and Ukraine), and increased protection (Moldova and Turkey) were other suggested mitigation measures. It must be noted that the percentages of all the recommended measures from the Ukrainian participants were surprisingly low.

Discussion

There is a clear geographical distinction between survey participants' perspectives in regard to wildfires as a serious threat. The northern Black Sea country participants (Romania, Moldova, and Ukraine) considered it a less serious threat than those from the southern Black Sea countries (Armenia, Greece, and Turkey) (Group 4 of CatPCA). This is due to the current dryer and more wildfire-prone climatic conditions in the southern Black Sea countries that corresponded well with the higher percentages of burnt forested areas (Table 1). It also corresponded well with the money spent on wildfires in these countries that were proportionally larger compared to the other countries (Table 1). All countries (except Turkey) had a substantially higher satisfaction for the existing personnel, compared to the equipment used and the implementation of ICT. This was very evident in Ukraine because wildfires are considered a smaller threat compared to the other countries in the region and they have an adequate number of firefighters while the money spent is substantially less compared to the other countries (Table 1 and Group 2 of CATPCA).

Greece, France, Italy, Portugal, and Spain have large investments of more than 2.5 billion euros every year in wildfire management (Biro and Mavsar 2009) but there is a growing scepticism whether firefighting with an airborne fleet justifies its high operational cost. The majority of the firefighting budget is spent on fire detection and suppression while it should be rather spent on preventive actions (Fernandes 2013). This current policy, results in the successful suppression of low to medium intensity wildfires in the Mediterranean, but not of large and high intensity wildfires (Tedim et al. 2013). Curt and Frejavile (2018) found that France's wildfire prevention was more effective, due to the new policy that decreased the number of wildfires substantially.

The satisfaction of the current designation of protected areas differed, with Ukrainian participants completely satisfied despite having one of the lowest percentages of protected areas compared to the other countries (Table 1). Participants for Greece and Armenia also showed satisfaction with the number of designated protected areas despite Greece having the lowest percentage of protected areas. In contrast, Armenia had the second highest

percentage of protected areas. A need for more protected areas was suggested by participants from Romania and Turkey and especially from Moldova. This finding was not expected in Romania that has a high percentage of their land protected (Table 1). For more effective management of the protected areas in all countries, except Ukraine, more personnel need to be hired and new equipment to be purchased or the current equipment to be upgraded. Finally, the greatest need appears to be in the use of ICT in the region, except for Turkey.

Wildfires are closely related to the management of protected areas (Suffling et al. 2008; Silva et al. 2013; Ager et al. 2014). Participants originating from countries where wildfires are considered a serious problem (Armenia, Greece, and Turkey) appear to have the greatest awareness of this interconnection. The CatPCA also indicates that the awareness seems to be higher in Armenia and Greece and in the female participants of the study (Group 4). This finding suggests that in the remaining countries, professionals and the general public need to be better educated on the interconnections between wildfires and the management of protected areas. In regard to the female participants, the lack of more information prohibits further analysis.

Climate change is expected to have major impact on both wildfire suppression and protected area management (Dury et al. 2011; Bedia et al. 2015; Jewitt et al. 2015). The Black Sea region participants also recognized the expected negative climate change impacts on both issues, although this was recognized more for wildfires. The CATPCA analysis revealed more awareness on climate-change potential impacts on wildfires in the more experienced participants (Group 1) whereas the younger ones were more troubled with the impacts in the protected areas (Group 3). At the country-level analysis, in all countries except Ukraine, the majority of participants expected the negative impacts of climate change to adversely impact both issues. As a consequence, this raises the question on the type of measures that should be taken to mitigate the potential adverse effects.

Forest management changes was the top measure suggested to mitigate climate change impacts for both wildfire suppression and management of protected areas. For wildfire suppression, vegetation interventions that reduce combustible fuels or promote more drought and fire-resilient environments could be implemented (Xanthopoulos et al. 2006, 2012; Fernandes 2013). It should be noted that woody biomass accumulates in most European forests, because 60–70% of the annual increment is harvested (European Commission 2015b), despite the increased demand for wood products. This underlines the need for action, especially in countries with high wildfire risk. Furthermore, an increase of forest operations could

significantly boost mountainous rural communities by increasing employment in forestry and its multiplier effect (Tsioras 2010, 2012). Forest management can also be a tool for the more effective conservation of protected areas (Ellis and Porter-Bolland 2008).

The measures suggested by the participants aiming at wildfire suppression and management of protected areas differed at the country level (Table 6). These findings are justified given the different environmental and political histories (Henderson et al. 2005). In Greece, Moldova, and Romania, participants overwhelmingly suggested changes in forest management as the most important measure to enhance wildfire suppression. Changes in forest management were the second most important measure for Turkish and Armenian participants.

Being proactive by taking appropriate management action is always the best way to mitigate any disaster. In Armenia and Ukraine, survey participants suggested the replacement of old equipment as the most important measure to suppress wildfires. This measure was also suggested as important in Romania. In Turkey, increased public awareness was ranked first; it was also considered an important measure in Greece, Moldova, and Romania. Staff training (Armenia and Greece), ICT implementation (Armenia and Romania) and better monitoring (Moldova, Turkey, and Ukraine) were also recommended. Implementation of ICT can be very effective in wildfire suppression (Alcasena et al. 2017). This follows suite with the participants' answers that ICT are underutilized in most surveyed countries.

Turkish participants again suggested increasing public awareness to improve the management of their protected areas as the most important measure. Greek participants also considered public awareness important. Changes in forest management were suggested as the most important measure in two countries (Moldova and Ukraine) and as the second most important in the other countries. In Armenia and Greece, the issue of better staff training was raised, which should focus on different groups. One such group is the forest workers, who are the practical implementers of forest management in Greece (Tsioras and Efthymiou 2007). Lack of specialized forest workers can become a problem in both wildfire suppression and the management of protected areas.

Romanian and Armenian participants brought up the issue of legislative changes, which could help the responsible agencies and organizations enhance the management of protected areas. Romanian participants also suggested better enforcement of the existing restrictions and penalties on activities that degrade protected areas by the responsible authorities. Some of the Romanian participants went one step further by proposing stricter restrictions and higher penalties.

Finally, better monitoring (Moldova and Ukraine) and increasing protection (Moldova and Turkey) were also suggested. Monitoring is very important in protected areas because it allows the evaluation of management plans (Hockings 1998). Finally, the percentages of all the recommended measures from the Ukrainian participants were surprisingly low. This is correlated with fact that the participants from this country had very high satisfaction rates from the personnel and the equipment for both issues (Table 3).

Conclusions

The on-going geopolitical and economic changes since the early 1990s along with climate change will have major impacts on the protected areas and the frequency of wildfires in the Black Sea region. These survey results provide recommendations that could be utilized by the agencies and organizations responsible for more effective management of wildfire suppression or protected areas of the region. Understanding similarities and differences among countries of the region is also essential to enhance their collaboration. Developing stronger cooperation among the people of the region will help, in the more effective management of natural resources and disasters in the Black Sea, because in many cases they do not follow political boundaries and extend through neighboring countries.

The countries from the southern part of the Black Sea region (Armenia, Greece, and Turkey) considered wildfires a substantially greater threat compared to the countries from the northern Black Sea region (Moldova, Romania, and Ukraine). Wildfires are likely to increase both in terms of frequency and magnitude in the Northern Black Sea countries, and awareness of wildfires and the interconnection between wildfires and protected areas should be enhanced. In regard to protected areas, participants from some countries considered the currently designated protected areas sufficient, while in others these areas should increase.

A major need in the region is to upgrade existing equipment and further utilize ICT to improve wildfire suppression and the management of protected areas. While there appears to be enough personnel to suppress wildfires, more are needed to be hired for the protected areas. Participants also suggested that climate change will increase wildfire frequency and negatively impact protected areas. Suggested measures to mitigate these impacts include changes and better management, increasing public awareness, replacing old equipment, legislative changes, staff training, ICT implementation, and better monitoring. Being proactive can help these countries face future climate change impacts more effectively.

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