

2012



EFICEEC Foresight for Research

Comparative Analysis of the Forest Fire Situation in Central-Eastern Europe



EUROPEAN FOREST INSTITUTE
CENTRAL-EAST EUROPEAN REGIONAL OFFICE – EFICEEC

EFICEEC Foresight for Research

Comparative Analysis of the Forest Fire Situation in Central-Eastern Europe

Written by

Jaspar Albers



Disclaimer:

The views expressed are those of the author and do not necessarily represent those of the European Forest Institute. This paper has been accepted as a Master Thesis at the University of Natural Resources and Life Sciences (BOKU) Vienna, Austria.



Published by

European Forest Institute Central-East European Regional Office (EFICEEC)
InFER – Institute of Forest, Environmental, and Natural Resource Policy
University of Natural Resources and Life Sciences, Vienna
Feistmantelstrasse 4, A-1180 Vienna, Austria

Tel.: (+43) 1 47654 4418

E-mail: eficeec@efi.int

Website: <http://www.eficeec.efi.int>

Edited, compiled and arranged by

Filip Aggestam





EUROPEAN FOREST INSTITUTE
CENTRAL-EAST EUROPEAN REGIONAL OFFICE – EFICEEC

TABLE OF CONTENTS

| | |
|--|----|
| Abstract | i |
| 1 Introduction to Forest Fires from a European Perspective | 1 |
| 1.1 A Threat for Europe | 2 |
| 1.2 Objectives, Hypotheses and Structure | 2 |
| 2 Material and Methods..... | 4 |
| 2.1 Evaluation Framework..... | 4 |
| 2.2 Scientific Literature Review | 4 |
| 2.3 Country Profiles..... | 5 |
| 2.4 Questionnaire for National Forest Fire Experts | 5 |
| 3 Study Region: Central-Eastern Europe | 6 |
| 3.1 Fire Situation..... | 6 |
| 3.1.1 Belarus (BY)..... | 7 |
| 3.1.2 Czech Republic (CZ)..... | 8 |
| 3.1.3 Poland (PL)..... | 9 |
| 3.1.4 Romania (RO)..... | 10 |
| 3.1.5 Slovakia (SK)..... | 10 |
| 3.1.6 Ukraine (UA)..... | 11 |
| 3.2 Natural Preconditions and Trends | 12 |
| 3.3 Forest Management | 13 |
| 3.4 Policy and Legal Frameworks..... | 14 |
| 4 Comparative Analysis of Questionnaire Results..... | 15 |
| 4.1 Fire Situation..... | 15 |
| 4.2 Natural Preconditions and Trends | 17 |
| 4.3 Forest Management | 19 |
| 4.4 Forest Management | 20 |
| 5 Discussion..... | 25 |
| 6 Conclusions for Central-Eastern Europe..... | 31 |
| 7 References | 33 |
| Appendix..... | 40 |



Abstract

The number of forest fire incidents has been increasing throughout the last decades and it is estimated that on average 600 000 ha of forests are burnt annually in Europe. In light of these developments and in view of the severe wildfire season in Russia during the summer of 2010, this study explicitly examines the forest fire situation in Central-Eastern Europe. Five hypotheses are formulated relating to the rising impact of forest fires, changing forest ownership structures and fragmentation, human influence on fire regimes, international cooperation, and public education. Scientific literature and specific country reports form the basis for a comparative analysis of the impacts and drivers of forest fires in the study region. The impacts are characterised by the category “Fire situation”, while the drivers are allocated to “Natural preconditions and trends”, “Forest Management”, and “Policy and legal frameworks”. Through the use of a questionnaire addressed to national forest fire experts, the study’s main focus is on six countries: Belarus, the Czech Republic, Poland, Romania, Slovakia, and Ukraine. Concerning the rising impact of fires it can be said that there is no uniform development of burnt area and number of forest fires in the region. This is due to the conversion of coniferous monocultures and more sophisticated fire fighting and forecasting techniques on the one hand. And on the other hand there is the locally varying influence of climatic changes, mostly by reduced precipitation and rising mean temperatures. Especially areas with neglected fuel management are recognized as threatened, for example the radioactively contaminated zones near Chernobyl in Ukraine and Belarus. Rural abandonment is identified as the most important socio-economic driver of wildfires in the region, with the additional problem of fragmented private forests, for example in Romania. Weak governance is a problem throughout the region and the legal measures in place are considered not to be effective enough to control human influence on forest fires. With regard to common framework approaches it is especially the EU member states which profit from further developments in this field. Public education measures receive an important status in Poland, where arson is a grave issue. The results indicate that prescribed burning will play a more prominent role in the future in achieving Integrated Fire Management. But legal and administrative frameworks must also be adapted to cope with changing ownership structures. Well prepared education campaigns can efficiently address anthropogenic influence on forest fires but cooperation with institutions outside the forestry or fire management sector is recommended. The possible development of an EU Fire Framework Directive will have positive impact on transboundary collaboration and also fuel management will be more affected by EU energy policies, as renewable forest biomass is growing in importance. The active involvement of NGOs and other stakeholders is necessary for successful fire management and also the issue of availability of reliable data is stressed with regards to further research.

1 Introduction to Forest Fires from a European Perspective

Naturally, wildfires¹ have been an integral element of European lowland forest ecosystems over much of the Holocene until the comparatively recent past (Niklasson et al. 2010). In most ecosystems without human influence, fire maintains dynamics and biological diversity. But almost since the dawn of mankind it has been either introduced into areas previously unaffected by it or, most prevalently, suppressed in large areas where fire occurred naturally (Benson et al. 2009). Due to industrialization and urbanization the use of fire was abandoned for decades but nowadays it is rapidly regaining importance as a management tool to replace and imitate natural processes in forestry, agriculture, and nature conservation (Myers 2006, FAO 2007, Birot 2009). Yet urbanization, abandonment of rural areas and shrinking budgets of fire authorities have increased the destructive impact of wildfires not only in Europe but worldwide (FAO 2007). A distinct rise of the number of forest fires in Europe has been shown by Schelhaas et al. (2003): While during the 1970s recorded fires averaged 40 000 annually, their number rose to above 95 000 in the 1990s (Fig. 1).

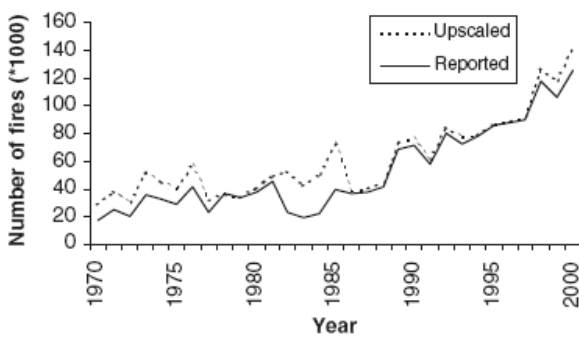


Figure 1. Annual number of reported forest fires in 30 European countries² from 1970-2000 (solid line). Upscaled number of fires

¹ An uncontrolled fire in combustible vegetation that occurs in the countryside or a wilderness area. Other names such as brush fire, bushfire, forest fire, grass fire, hill fire, peat fire, vegetation fire and wildland fire may be used to describe the same phenomenon depending on the type of vegetation being burned (FAO 2005).

² Countries included: Albania, Austria, Belgium, Bosnia & Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the FYR of Macedonia, The

(dashed line) for total Europe (Source: Schelhaas et al. 2003, p. 1623).

An increase can also be seen for the average burnt forest area in Europe (Fig. 2). A rough estimation gives the annual area with 227 000 ha, over the period from 1991 to 2000 (Schelhaas et al. 2003). This translates into approximately 0.16% of the total forest area in Europe. Recent studies, relying on more accurate data, even estimated an average of 600 000 ha of forests that are burnt by wildfires in 23 European countries³ annually (Barbosa et al. 2009). More than 80% of the burnt area usually occurs in the Mediterranean region (San-Miguel & Camia 2009), where certain countries have experienced large and uncharacteristic fire events in 2003 (Portugal) and 2007 (Greece). In 2010, a total of 274 000 ha of forests were burnt in Europe according to the Joint Research Center of the European Commission (JRC), a figure which was well below the long term average. About 60% of that area was located in Portugal alone (Schmuck et al. 2010). The large share of forest fires in the Mediterranean countries justifies growing concerns within that region. But as the extreme climatic conditions of the recent past also affected other parts of a densely populated Europe, the question arises whether current policies and measures related to fire management are efficient enough (Birot 2009).

Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and Yugoslavia (now Serbia, Kosovo, and Montenegro).

³ Data from EFFIS database for the period 2000-2005 covered Austria, Cyprus, Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Croatia, Switzerland, Turkey, and Norway.

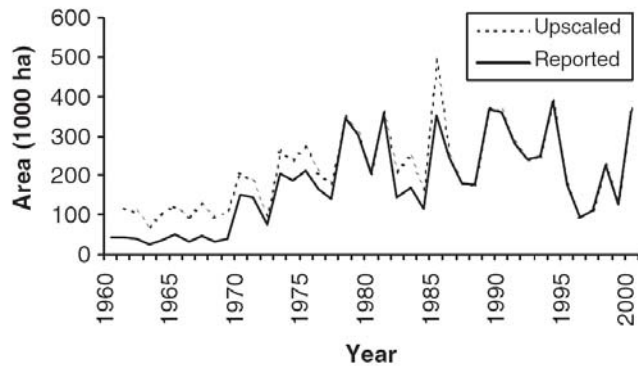


Figure 2. Burnt area of reported forest fires in 30 European countries⁴ from 1960-2000 (solid line). Upscaled burnt area (dashed line) for total Europe (Source: Schelhaas et al. 2003, p. 1623).

In Mediterranean countries where wildfires have a profound influence on ecosystem dynamics, authorities have developed effective legal regulations towards fire management⁵. On the other hand countries in Northern, Central or Eastern Europe still lack competent frameworks as destructive wildfires are a comparatively recent threat (Herrero et al. 2009, Montiel & Herrero 2010).

1.1 A Threat for Europe

One recent example of wildfires with severe large-scale impacts in Europe took place in Western Russia during the summer of 2010, when the region experienced a heat and drought period unprecedented in its documented weather records (Goldammer 2010). The resulting conditions

⁴ Countries included: Albania, Austria, Belgium, Bosnia & Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the FYR of Macedonia, The Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and Yugoslavia (now Serbia, Kosovo, and Montenegro).

⁵ All activities required for the protection of fire prone forest and other vegetation values from fire and the use of fire to meet land management goals and objectives. It involves the strategic integration of such factors as knowledge of fire regimes, probable fire effects, values-at-risk, level of forest protection required, cost of fire-related activities, and prescribed fire technology into multiple-use planning, decision making, and day-to-day activities to accomplish stated resource management objectives. Successful fire management depends on effective fire prevention, detection, and pre-suppression, having an adequate fire suppression capability, and consideration of fire ecology relationships (FAO 2005).

facilitated ignition and spread of wildfires during a particular episode from 21 June to 19 August 2010. The fires took place on an area pending between 300 000 to 400 000 ha, which is comparatively small in relation to the total Russian territory. Nevertheless, they affected about 14 million people by exceedingly high degrees of air pollution, including Moscow and its suburbs (Goldammer 2010, Schmuck et al. 2011). During the whole fire season the area burning nationwide amounted to 2.3 million ha (Schmuck et al. 2011). A daily mortality rate of 700 persons during days of extreme heat and smoke pollution was noticed in Moscow, where the average varies between 350 and 380 persons (Goldammer 2010). More than 200 000 fire fighters and 200 aircraft were deployed during these events, with fourteen other countries providing further assistance (Schmuck et al. 2011).

Since the 1990s, forest fires in Russia have significantly increased (FAO 2006a, Goldammer et al. 2008), a trend that is mirrored on a worldwide scale and especially in the rest of Europe (Fig. 1). The 2010 Russian wildfires have gained broad public and political attention, not only within Russia but there it has been one of the rare events that forced officials to react, as daily life in Moscow was seriously influenced (Goldammer 2010).

1.2 Objectives, Hypotheses and Structure

The recent events in Western Russia have increased public attention to fire management not only in affected countries but over most of Europe. Impacts of wildfires are not limited to the respective areas or regions but affect ecosystems and livelihoods of people on a larger scale. With the 2010 wildfires in mind, this study examines the current forest fire situation in adjacent Central-East European (CEE) countries. This region exhibits comparable natural conditions and finds itself in a similar socio-economic transition phase since 1990.

The main question is the future importance of wildfires for forest management. Since fire weather conditions and tree species distribution, either due to natural or anthropogenic reasons, will be subjected

to changes in the future the first hypothesis is formulated as follows:

Hypothesis I:

Due to the increase of average burnt area and number of wildfires, their active management will become an even greater aspect of the sustainable use of forests in CEE.

The ongoing transition of national economies has multiple effects. Directly related to forest fire management are land-use changes predominantly in rural areas, hence:

Hypothesis II:

Changing forest ownership structures and land fragmentation due to restitution⁶ and privatization⁷ in CEE affect present and future fire regimes.

As these changes can also lead to weakened governance in the forestry sector, it is important to find out whether this is addressed by existing policies and whether fire management capabilities will further decrease:

Hypothesis III:

Policies and law enforcement measures by official agencies in CEE are insufficient to control human influence on forest fire regimes.

Transboundary cooperation is mostly limited to emergency cases, as forest fires are still a matter of national legislative. Therefore, the fourth hypothesis aims at the highly diversified regulations within the study region:

⁶ **Restitution** of forests acknowledges the continuity of private ownership rights on forestland in returning them to the former owners or their heirs and/or to local communities and institutions (Schmithuesen & Hirsch 2010, p. 43).

⁷ **Privatization** refers mainly to the process of creating new private property rights on forest land within the scope of this study. Privatization increases competition and commercialization by reducing the role of the public sector and is concerned with transferring tenure and management rights to private individuals and corporate bodies (Schmithuesen & Hirsch 2010, p. 43).

Hypothesis IV:

Common international framework approaches can strengthen the efforts directed at managing forest fires in CEE, especially within the scope of EU policies.

Throughout all these issues, reliable information impacts fire management, scientific research, and decision making processes. Heterogeneous methods for collecting and processing data on forest fires or scarce publications in English can thus further inhibit fire prevention. The importance of public education measures and long-term effects of lessons learned after severe fire events seems obvious:

Hypothesis V:

Public education and access to relevant data are important tools in fire prevention as human-caused fires prevail in CEE.

Scientific publications, case studies and country reports presented in the second chapter provided the fundamental data. Drivers and impacts of forest fires in Eastern Europe are closely examined in the third chapter. An additional questionnaire addressed to national forest fire experts laid the basis for a comparative analysis of the forest fire situation in different countries in the fourth chapter. The analysis is meant to address the formulated set of hypotheses in the fifth and lead to final conclusions in the sixth chapter.

2 Material and Methods

2.1 Evaluation Framework

For a start, the principles and strategic actions of the voluntary fire management guidelines by the Food and Agriculture Organization of the United Nations (FAO 2006b) provide a valuable orientation. Based on the literature review certain criteria are chosen to address the issues highlighted by the hypotheses. Up to a certain extent, these cover climatic and natural preconditions as well as silvicultural tools and measures employed by the respective forest services in the prevention of fires. Also, the development of policies and national frameworks in the field of forestry and land-use management is examined, as all of the CEE countries experience socio-economic changes since the 1990s. An identification of common wildfire problems and issues is the main reason for applying criteria that fit to all targeted countries. The factors, which could generally be described as framework conditions for forest fire management are arranged in four separate categories:

Fire situation, this category comprises causes of wildfires and its characteristics. It provides the basis to compare the current conditions for fire management.

Natural preconditions and trends, which include ecological factors, their influence on wildfire regimes and the possible impact of climate change.

Forest management, with the aim of identifying obstacles for forest owners and managers when dealing with wildfires. This includes fire prevention but also the active use of fire to see whether existing measures are adapted to the respective situation.

Policy and legal frameworks, which stretches over different criteria. It targets structural problems of forest policies and its implementation. But also land-use changes, restitution and privatization processes of economies in transition are of interest.

The criteria-based assessment of relevant forest fire factors and their continuous retention during the

progression of the study allows for a comparative analysis on country level. This is based on three pillars: Scientific publications and country reports which are used to gather material are presented in the next two paragraphs. A questionnaire for national forest fire experts is described in the fourth paragraph. It is a method employed to gain additional knowledge and an assessment of local forest fire issues. The countries originally targeted by this study are Belarus, Bulgaria, Czech Republic, Hungary, the former Yugoslav Republic (FYR) of Macedonia, Poland, Romania, Slovakia, and Ukraine (Fig. 3). But since the questionnaires were not replied by Bulgaria, Hungary and the FYR of Macedonia these three countries are omitted from the study.

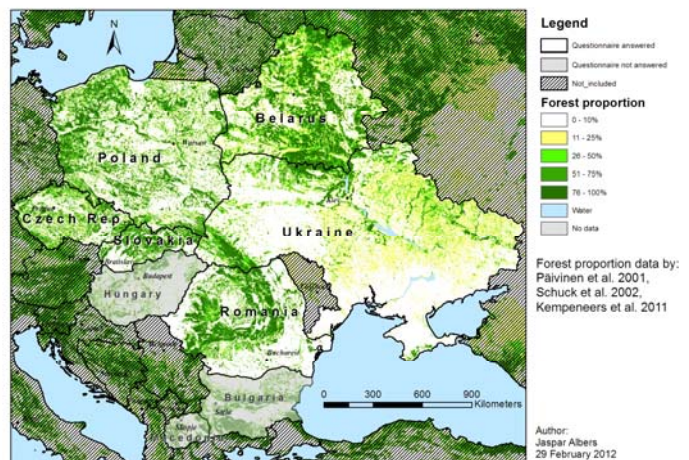


Figure 3. Overview of study region with participating, non-participating and non-included countries.

2.2 Scientific Literature Review

In general, research mainly focuses on remote sensing for fire detection, carbon pools and fluxes affected by fire under anthropogenic and climatic influence (FAO 2007). Obtaining useful contributions with a focus on Central-Eastern Europe or merely Europe as a whole is complex work. According to Flannigan et al. (2009), almost 75% of the publications dealing with wildland fire and climate change stem from North America. In the paper they also concisely explain the correlation between

climate and wildland fire on a global scale with prospect on climate change implications. The main source for publications related to the topic is the bibliographic database Scopus of Elsevier's SciVerse, which is licensed by both BOKU University and the University of Eastern Finland. A short but comprehensive overview of the role of fire in Earth's history is provided by Bowman et al. (2009), while Niklasson et al. (2010) attempt to reconstruct a fire history in the European temperate lowlands for the primeval forest in Białowieża, on the border between Poland and Belarus. Concentrating on Europe, a study on fire effects on forest resources in the French Mediterranean region under climate change scenarios is done by Meyer (2005) and an overview of fuel management⁸ in Europe is given by Xanthopoulos et al. (2006). One major European project is the "Fire Paradox" research, launched by the European Commission (EC) in 2005 within the Sixth Framework Programme. Its results are published by Silva et al. (2010) and Montiel & Kraus (2010) in collaboration with the European Forest Institute (EFI). Another EFI paper on the topic of wildfires in Europe is edited by Birot (2009) to contribute to policy making processes.

2.3 Country Profiles

Country specific data on forest fires including empirical fire statistics, climate conditions and policy frameworks are obtained from different sources. Sporadic country reports have been published by the Global Fire Monitoring Centre (GFMC) in its International Forest Fire News (IFFN) until 2007. These have been compiled in collaboration with the FAO/United Nations Economic Commission for Europe (UNECE) Team of Specialists on Forest Fire on behalf of the UNECE Timber Committee and the FAO European Forestry Commission. The countries covered by this study are further organized in two Regional Wildland Fire Networks under the auspices of the UN International Strategy for Disaster Reduction. One is the Regional Eurasian Wildland Fire Network, involving the northern temperate-

⁸ Act or practice of controlling flammability and reducing resistance to control of wildland fuels through mechanical, chemical, biological, or manual means, or by fire, in support of land management objectives (FAO 2005).

boreal countries like Belarus, Poland, Russia and Ukraine since the late 1990s. The other is the Regional Southeast Europe/Caucasus Wildland Fire Network, uniting Romania and Ukraine among others. This network has been officially established as the Regional Fire Monitoring Centre by the GFMC and the Council of Europe in 2010. Relatively recent country reports are provided by these networks, although it has to be noticed that neither the Czech Republic nor Slovakia are part of the respective networks. The reasons for including all these specific countries in the study are on the one hand comparable ecologic and socio-economic conditions; and on the other hand the availability of reliable data and publications. To this, the annual European Forest Fire Information System (EFFIS) reports on forest fires in Europe by the JRC are a great contribution. The latest report on the 2010 fire season has been released on 18 August 2011 and provides official statistics on number of fires and burnt areas for the participating countries. For the countries of interest it dates back up to 1990. EFFIS has been established at the JRC in 2003 to conduct fire risk calculations and forecasts at EU-level for the Directorate General of the European Commission for Environment (JRC 2010).

2.4 Questionnaire for National Forest Fire Experts

To account for an apparent lack of reliable scientific publications in English in the targeted region it is seen as necessary to conduct a special survey. This is addressed to selected forest fire experts from each of the respective countries. The questions are aimed at determining natural and socio-economic drivers of forest fires in each country. Furthermore, forest management and legislative frameworks are to be assessed according to the categories described in the opening paragraph of this chapter. In conclusion, indicators are chosen for the decisive criteria and organised according to the four categories, which result in altogether 22 questions. To obtain comparable answers for the following assessment, most answering options range from pre-defined choices in tables to short descriptions of certain given characteristics. The recipients themselves are selected from the current FAO/UNECE Team of Specialists on Forest Fire. As this group does not

cover the entire target region it is supplemented with contributors to the annual EFFIS report. In the case of the Czech Republic, which does not have a representative in any of those groups, a search of scientific publications related to forest fires results in a capable contact.

The first part (“1. Contact Information”) asks for contact details of the respondent to facilitate further direct enquiries. The second part (“2. Fire Situation”) aims at obtaining information about certain local forest fire characteristics. With the third segment (“3. Natural Preconditions and Trends”), the questionnaire compiles data about fire prone forest areas and the possible influence of climatic change on wildfire regimes. In the fourth part (“4. Forest Management”), biomass supply and issues of forest fire prevention are thematised. The last part with pre-defined choices (“5. Policy & Legal Framework”) aims at obtaining information about policy making and implementation regarding forest fires. Lastly, in the sixth part the respondents have the opportunity

3 Study Region: Central-Eastern Europe

In Europe, but also worldwide the fire situation is deteriorating and the impacts can be severe as the example of Russian wildfires has shown. But behind the current situation are different drivers responsible for favourable fire conditions. Natural and especially climatic factors usually predefine the stage for forest fires. Management effects in forests add another component and influence the accumulation of fuels⁹ due to fire suppression and the continually expanding wildland-urban interfaces¹⁰ (WUI) (Rigolot et al. 2009, Véléz 2009). Consequently, the pattern of forest fire distribution is not only determined by climatic conditions but also socio-economic factors (San-Miguel & Camia 2009). In many cases the limited availability of workers and fire fighters in rural areas leads to an increase of fires from agricultural clearance running out of control

⁹ All combustible organic material in forests and other vegetation types, including agricultural systems, such as grass, branches and wood, which create heat during the combustion process (FAO 2005).

¹⁰ The transition zone where structures and other human development meets undeveloped wildland or vegetative fuels (FAO 2005).

to share their own opinion on additional important domestic issues in wildfire management and refer to available publications on the topic.

The questionnaire is designed to collect information on a qualitative scale with exceptions, when questions 2.1 and 2.2 deal with quantitative attributes and questions 3.6 and 5.1 implicate a ranking of factors based on expert knowledge. The questions themselves are designed to address specific criteria each. This leads to variations in the pre-defined answering options, although these are arranged in a way to still allow for a comparative analysis. In questions that include estimations on future trends, the respondents are asked to picture the respective situation in about ten years. To use further leaps in time is not seen as realistic due to the spatial scope of this study and simple unpredictable aspects of natural dynamics. Using shorter periods might yield even less noticeable differences. All questions include text boxes that allow for remarks and further explanations by the respondent.

(FAO 2007). These problems are strongly influenced by national policies.

Taking into account the categories introduced in chapter 2, the “Fire Situation” is considered as the original impact caused by forest fires in the region. Therefore, the drivers are accordingly represented by “Natural Preconditions and Trends”, “Forest Management”, and “Policy and Legal Frameworks” in the following sections. A concise overview of forest ownership, forest fire statistics, prevention and extinction techniques, and damages caused by forest fires for each of the involved countries is included in the section “Fire Situation”. This is meant to provide a direct basis for comparison on the country level and to put the overall regional findings into perspective.

3.1 Fire Situation

Apart from natural factors, the fire situation in CEE is strongly influenced by socio-economic factors, which could be simplified with terms as, for example, gross domestic product, population density or livestock.

The explicit connections and interactions between these factors are examined mainly in the Mediterranean basin where, during the last decades, changes in fire occurrence have also closely reflected socio-economic changes (e.g. Catry et al. 2009, Koulelis & Mitsopoulos 2009, Montiel & Herrero 2010). Urbanization due to rural abandonment and agricultural mechanization leads to the problem of fuel accumulation (Moreno & Oechel 1994, Pausas & Vallejo 1999, FAO 2007). This is especially experienced by economies in the transition phase towards open-market conditions (FAO 2007).

Agricultural burning, a common practice all over Eastern Europe during spring and early summer (Goldammer 2010), becomes more problematic as traditional know-how of burning methods is lost during the progressing changes (Montiel & Herrero 2010). In general, a shift in priorities from timber production towards nature conservation and recreation is taking place. Especially with cottages springing up on a huge scale in urban outskirts this development leads to an increased WUI (Montiel & Herrero in Silva 2010). All these factors and processes influence the fire risk on a general European scale, but it is also important to stress that compared to the Mediterranean basin consistent and long-term fire records in Central European forests are sparse (Niklasson et al. 2010, Vacik et al. 2011).

In general, investments made for wildfire prevention and suppression in CEE are not as high as in Mediterranean areas, e.g. EUR 2.5 billion annually for Greece, France, Italy, Portugal, and Spain combined (Birost & Mavsar 2009). Still the losses caused by severe wildfire events can be considerable. During the 2007 wildfires in Greece, 64 people lost their lives and damages of EUR 5 billion were caused (Birost & Mavsar 2009). While the conditions in CEE show no indication of reaching those dimensions it is important to know that wildfires also cause significant damages to ecosystems and their processes. Therefore they are usually underestimated (Birost & Mavsar 2009, Mavsar 2009). Furthermore, smoke from wildfires, along with emitted combusted organic matter and toxic particles (e.g. lead, mercury, cadmium), has serious impacts on human health (Goldammer et al. 2009a). And despite their usual distance from such events,

air pollution stemming from wildfires can be as severe in urban areas as it is in rural areas (Schwela et al. 1999). Forest fires can have an impact over long distances, for example even several thousands of kilometres from the Canadian boreal forests to Central Europe (Forster et al. 2001). Niemi et al. (2005) prove that wildfires occurring in Eastern Europe and Russia have negative effects on air quality in central areas in Finland. This adds to a definition by Hardy (2005) stating that the spatial impact of wildfires ranges from site to continent, while the temporal scale of its impacts can vary from minutes even to centuries.

3.1.1 Belarus (BY)

Forest area

The total extent of the area covered by forests in Belarus amounts to 8.6 million ha, about 42% of the total country area (FAO 2010). Coniferous species are predominant, i.e. *Pinus sylvestris* (56%) and *Picea abies* (11%), while *Betula* spp. constitute the largest group of deciduous trees with 18% (Mysleiko & Shamal 2001). Even-aged forest stands as well as the composition of tree species are due to strong anthropogenic influences (Usenya & Katkova 2004). Private forest ownership does not exist in Belarus (Mysleiko & Shamal 2001).

Fire statistics

For the period of 1990 until 2000, information about wildfires in Belarus can be found in the IFFN country report by Mysleiko & Shamal (2001). For the subsequent years until 2009, the fire statistics are obtained from the “Bellesavia” group within the Ministry of Emergency Situation of Belarus (D. Dziamyanau, personal communication, 5 July 2011). As data for forest fires alone are only partially available, the graph in figure 4 also includes fires occurring on other land-use forms than forests.

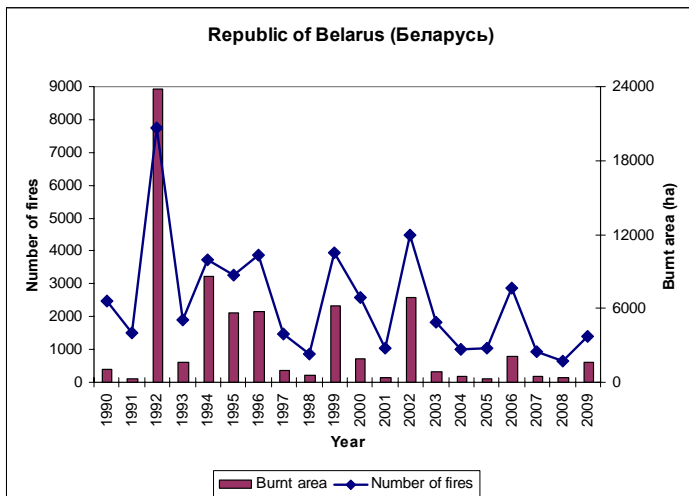


Figure 4. Annual number of wildfires (blue line) and burnt area (red columns) for Belarus (Sources: Mysleiko & Shamal 2001; D. Dziamyana, personal communication, 5 July 2011).

Fire prevention and extinction

Forests in Belarus are divided into five Fire Hazard Classes: The first two classes with the highest hazard classifications contain about 60%, while the class with the lowest hazard comprises roughly one percent of the forest area. The most endangered stands are middle-aged coniferous forests, especially when exhibiting rich understorey vegetation which facilitates crown fires. Common prevention measures include silvicultural activities, including the introduction of broadleaved tree species and thinning operations, along with the construction of fire- and fuelbreaks (Mysleiko & Shamal 2001). For an early detection and monitoring of forest fires, aerial patrols are regularly employed, while during the process of firefighting fire brigades can draw on sand blowers which can be deployed on sandy soils (FAO 2007). This technique is not mentioned as a fire extinguishment measure in other countries.

Damages caused by forest fires

A damage assessment in 2004 by Usenya & Katkova (2004) concludes that annual financial damages from wildfires average USD 700 000. Further indirect damage to the actual

ecosystems is estimated with USD 340 000 annually.

3.1.2 Czech Republic (CZ)

Forest area

The total extent of the area covered by forests in the Czech Republic amounts to 2.7 million ha, about 34% of the total country area (Forest Management Institute 2007, FAO 2010). Due to restitution processes, which are drawing to a close, the share of forests belonging to the state has decreased significantly from 95.8% in 1991 to 60.1% in 2006 (Schmithuesen & Hirsch 2010). Nowadays, forest holdings greater than 100 ha represent around 50% of the total area owned by private persons or companies (Schmithuesen & Hirsch 2010), while holdings smaller than six hectares represent almost 30% (Hirsch et al. 2007).

Fire statistics

For the period of 1995 until 2006 in figure 5, information about forest fires in the Czech Republic can be found in the EFFIS report on forest fires in Europe 2010 by Schmuck et al. (2011). For the subsequent years until 2009, the fire statistics are obtained from the Ministry of Agriculture of the Czech Republic (2010).

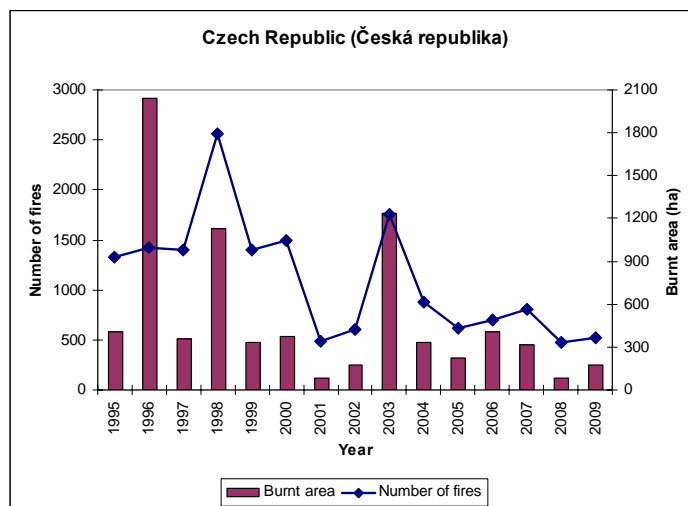


Figure 5. Annual number of forest fires (blue line) and burnt area (red columns) for the Czech Republic (Sources: Ministry of Agriculture of the Czech Republic 2010; Schmuck et al. 2011).

Fire prevention and extinction

Aerial patrols are employed for early detection and monitoring as well as fighting of fires (Sisak et al. 2004). Other methods are applied as well but without explicit reference in English publications.

Damages caused by forest fires

A damage assessment by Sisak et al. (2004) concludes that for the period from 1996 to 2001 financial damages from forest fires amounted to EUR 3.39 million.

3.1.3 Poland (PL)

Forest area

The total extent of the area covered by forests in Poland amounts to 9.3 million ha, about 30% of the total country area (FAO 2010). An increase of private forest area is mainly due to afforestation efforts on agricultural lands. The number of private owners increased only slowly, as neither privatization nor restitution of forest land has taken place so far (Schmithuesen & Hirsch 2010). Fragmentation is one of the basic problems of private forest ownership, as holdings smaller than six hectares represent almost 70% of the total area owned by private persons or companies (Hirsch et al. 2007, Schmithuesen & Hirsch 2010). Coniferous tree species dominate around 75% of the total forest area where even-aged monocultures of *Pinus sylvestris* are very common, especially on poor soils (Ubysz & Szczygiel 2002).

Fire statistics

For the period of 1990 until 2009 in figure 6, information about forest fires in Poland is obtained from the EFFIS report on forest fires in Europe 2010 by Schmuck et al. (2011).

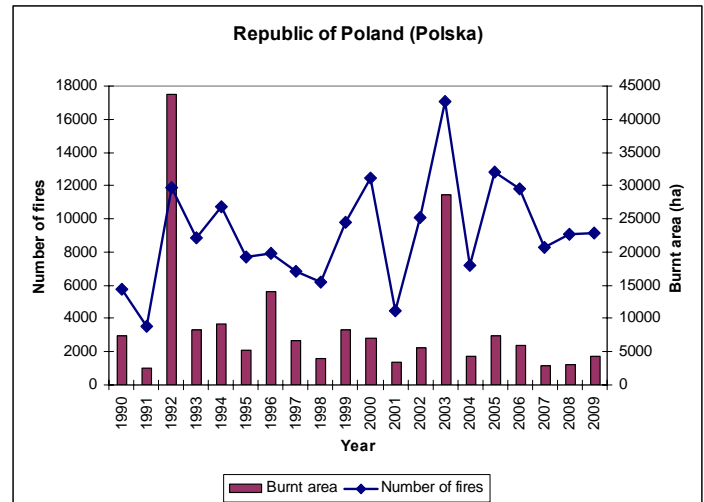


Figure 6. Annual number of forest fires (blue line) and burnt area (red columns) for Poland (Source: Schmuck et al. 2011).

Fire prevention and extinction

Neglected forest management leads to an accumulation of fuels which means that especially private forests fall under the highest of the three existing fire danger classes. Forests are usually categorized on the district level in 10-year intervals according to site type, age structure, climatic conditions, and fire frequency. The proximity to urban or industrial areas and influences of industrial pollution are further important parameters (Ubysz & Szczygiel 2002). Common prevention measures include silvicultural activities as well as the construction of fire- and fuelbreaks (Szczygiel & Piwnicki 2011). Aerial patrols are employed for early detection and suppression of fires (Ubysz & Szczygiel 2002, Szczygiel & Piwnicki 2011).

Damages caused by forest fires

Ubysz & Szczygiel (2002) conclude that forest fires have caused on average a direct annual loss of about EUR 61 million. The magnitude of these losses might further increase, as an assessment by Schelhaas et al. (2010) shows that Poland will experience an increase in forest fire risk in a modelling time frame until 2100.

3.1.4 Romania (RO)

Forest area

The total extent of the area covered by forests in Romania amounts to 6.6 million ha, about 29% of the total country area (FAO 2010). The private forest area has strongly increased since 1990 and around two million ha are still about to undergo restitution, which will bring further changes to the presently predominant public ownership structure (Schmithuesen & Hirsch 2010).

Fire statistics

For the period of 1990 until 2009 in figure 7, information about forest fires in Romania is obtained from the EFFIS report on forest fires in Europe 2010 by Schmuck et al. (2011).

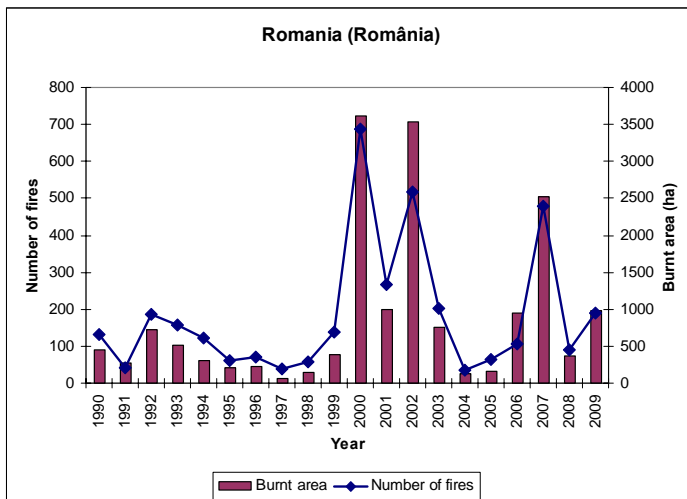


Figure 7. Annual number of forest fires (blue line) and burnt area (red columns) for Romania (Source: Schmuck et al. 2011).

Fire prevention and extinction

Forest fire risk evaluation is based on norms developed by the French 'Centre national du Machinisme Agricole, du Génie Rural, des Eaux et Forêts' research institute due to similar forest structures in both countries (Mara 2003a). Common prevention measures include silvicultural activities as well as the construction of fire- and fuelbreaks. Aerial patrols are

employed for early detection of fires (Mara 2003b).

Damages caused by forest fires

The fire season with most fires so far took place in 2000 and has led to estimated economic losses of USD 161 081 with one single fire event already causing damage of around EUR 70 000 (Mara 2003b). Nonetheless, figures estimated for country-wide forest fires in combination with a major storm event in 2002 equal a total economic loss of EUR 550 000 (Mara 2003a). Economic losses are comparatively low, as only the actual forest and timber values entered the damage calculation, and most fires only affected young forest stands (Mara et al. 2011).

3.1.5 Slovakia (SK)

Forest area

The total extent of the area covered by forests in Slovakia amounts to 1.9 million ha, about 40% of the total country area (FAO 2010). Before 1991, all forests have been managed by state forest enterprises which nowadays still represent a major share in the ownership distribution (Schmithuesen & Hirsch 2010). Privatization of public forest holdings has mostly come to an end, while the restitution process has not yet been completed. Individual forest plots remaining are of small size and thus not very attractive for private owners (Hirsch et al. 2007, Schmithuesen & Hirsch 2010). Future changes in forest ownership structure to a certain extent are thus still to be expected (Hirsch et al. 2007). In mountainous areas, forests are usually dominated by dense and even-aged coniferous stands (Majlingová & Sedliak 2010).

Fire statistics

For the period of 1994 (1999 for burnt area) until 2009 in figure 8, information about forest fires in Slovakia is obtained from the EFFIS report on forest fires in Europe 2010 by Schmuck et al. (2011).

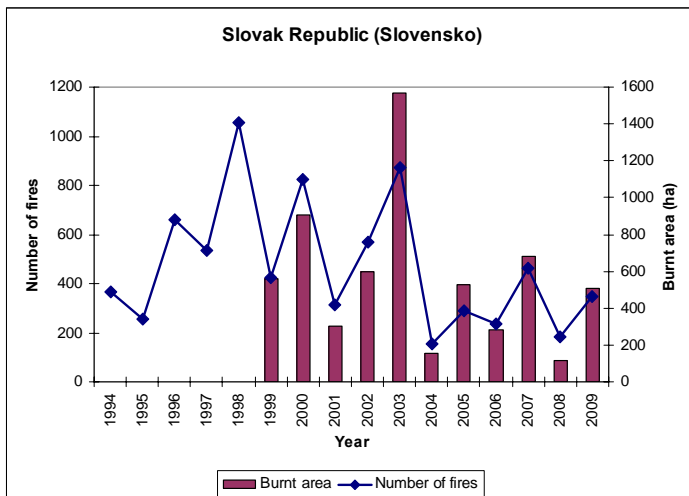


Figure 8. Annual number of forest fires (blue line) and burnt area (red columns) for Slovakia (Source: Schmuck et al. 2011).

Fire prevention and extinction

A fire pre-warning system for forests in Slovakia has not yet been set up, although the Slovak Hydrometeorology Institute has started to disseminate meteorological warnings by June 2010. Aerial firefighting units are especially employed in inaccessible mountainous terrain where fires occur on a usual basis (Majlingová & Sedliak 2010).

Damages caused by forest fires

On an experimental site in the Slovensky Raj National Park in the eastern part of Slovakia, occurrence and impact of wildfires are the main topic of a large number of studies (e.g. Tucek & Majlingová 2009, Majlingová & Sedliak 2010). The damage calculations vary from EUR 0.1 million to EUR 12.2 million for local fire events in 2007 and 2000, respectively (Majlingová & Sedliak 2010). On an overall scale, it is estimated that forest fires cause on average an annual loss of about EUR 8 million (Tucek et al. 2004).

3.1.6 Ukraine (UA)

Forest area

The total extent of the area covered by forests in Ukraine amounts to 9.7 million ha, about 17% of the total country area (FAO 2010). The state

owns up to 97% of the forest and its state forestry committee manages around 68% of these (Zibtsev 2007). *Pinus sylvestris* dominates the species distribution with 33%, of which the young and middle-aged monocultural stands (70%) are especially relevant for fire management (Zibtsev 2007, Zibtsev 2008). The other relevant species is *Picea abies* (7.5%) whose occurrence is lumped in the Carpathian Mountains (Zibtsev 2008).

Fire statistics

For the period of 1990 until 2007, information about wildfires in Ukraine (Fig. 9) can be found in the RFMC country report by Zibtsev (2007). For the subsequent two years, the fire statistics are obtained from sources only published in Ukrainian (Kuzyk & Popovych 2010, Y. Yanko, personal communication, 6 July 2011).



Figure 9. Annual number of wildfires (blue line) and burnt area (red columns) for Ukraine (Sources: Zibtsev 2007; Kuzyk & Popovych 2010; Y. Yanko, personal communication, 6 July 2011).

Fire prevention and extinction

Fire risk predictions are based on the Nesterov Index for meteorological data (Zibtsev et al. 2011), but according to Zibtsev (2010), an efficiently working fire management system only exists for about 68% of the forests. Common prevention measures include the construction of

fire- and fuelbreaks. Aerial firefighting units are especially employed in case of large wildfires (Zibtsev 2007).

Damages caused by forest fires

A large forest fire (7 300 ha) in 2007 has caused a damage of about USD 15.8 million (Zibtsev 2007). For a whole period from 2004 to 2009 the damage of forest fires has been estimated to amount to USD 36.9 million (Zibtsev 2010).

3.2 Natural Preconditions and Trends

Almost the entire study region lies within the temperate vegetation zone (Fig. 10), where natural forests on fertile soils are usually dominated by broadleaved trees (FAO 2007). In their western parts, the Czech Republic and Poland are temperate oceanic (Toc), with a gradual transition to temperate continental climate (Tco) towards the East of the region. While most countries exhibit temperate continental steppic characteristics in areas with low precipitation, Romania and Ukraine are defined even as temperate xeric steppic (Txest) close to the Black Sea. Only the south-eastern edges, stretches of land in Romania and Ukraine directly at the Black Sea coast, fall within the Mediterranean pluviseasonal continental steppic (Mpcst) bioclimatic zone (Rivas-Martínez et al. 2004). Accordingly, European beech (*Fagus sylvatica*) is the most common deciduous tree in the study region, while forests of oak (*Quercus* sp.) and other species can be found locally (Szczygiel et al. 2009). Fire prone forest ecosystems on dry sites are usually dominated by pines, mostly Scots pine (*Pinus sylvestris* L.) (FAO 2007). Coniferous species have been used by man to re- or afforest large areas in the study region for the last two centuries; apart from Scots pine Norway spruce (*Picea abies*) is predominant (Szczygiel et al. 2009).

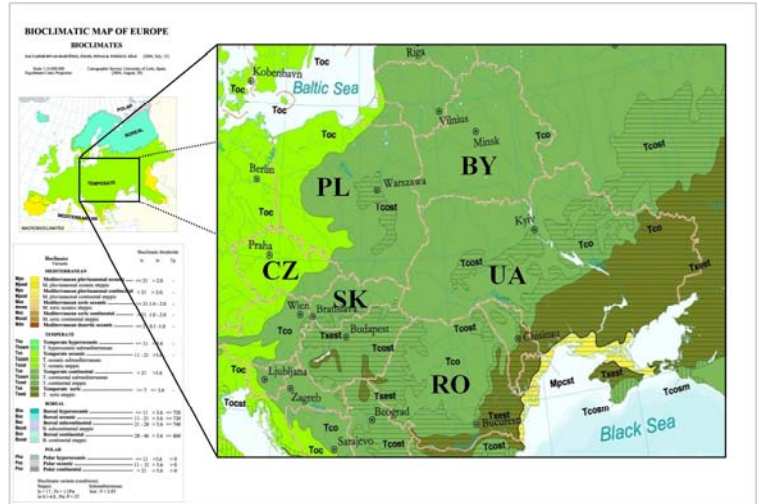


Figure 10. Bioclimatic zones in Central-Eastern Europe¹¹, defined by climate and vegetation characteristics (Source: Rivas-Martínez et al. 2004; modified).

The ignition of and the environmental conditions for wildfires are directly influenced by climatic factors, which also determine the distribution and productivity of forests (Benson et al. 2009). A changing climate has direct implications on fire regimes through altered precipitation, temperature, and wind patterns. An indirect effect is the change of fire fuels through a long-term shift of tree species. Results from Seidl et al. (2011) already show that climate change is the most important driver behind the increase in area burnt in European forests from 1958 to 2001. As the regional studies on climate change in Europe usually focus on boreal (e.g. Goldammer 1996, Stocks et al. 1998, Flannigan et al. 2009) or Mediterranean forests (Moriondo et al. 2006), no specific scenarios exist for the CEE region. Although projected climate change scenarios for a larger region still lack accuracy, the intensity, duration and frequency of heat waves are expected to increase in Central Europe (Moreno 2009). This might lead to an increased length and severity of the fire season, plus an extension of areas with high fire risk. More specifically, Lorz et al. (2010) predict an increase of up to 90% of the forest areas with

¹¹ The names of the six countries covered by this study are abbreviated with the codes defined by ISO 3199.

high fire probability in Central and South-Eastern Europe. According to other studies on effects of global change in Europe (e.g. Maracchi et al. 2005, Schroeter et al. 2005) there is a clear trend towards warmer temperature recognizable that shows important regional variations. Concerning precipitation, results show a decrease of precipitation in southern Europe while the northern parts can experience an increase in rainfall, especially during the summer season (Schroeter et al. 2005).

In the circumboreal zone, precipitation is the most important factor for wildfire regimes, especially for fire frequency according to Flannigan et al. (1998). Their study also suggests that climatic factors have a much stronger influence on fire frequency than human behaviour. In Russian boreal forests for example, the number of wildfires is expected to increase, as occurrence of fires usually depends on severe fire weather. However, the area burnt might not necessarily increase, as fire spread is more strongly influenced by topography, land-use, and fire fighting and suppression tactics (Malevsky-Malevich et al. 2008).

Particularly in the temperate continental zone the impact of climate change can increase exposure and sensitivity to wildfires (Lindner et al. 2010) as well as wildfire risk in the mountainous Balkan region (Moriondo et al. 2006). Water availability for trees is expected to be more limited than in the past which, along with presumable increases in temperature, can result in higher drought frequency (Moreno 2009, Lindner et al. 2010).

3.3 Forest Management

According to Schmithuesen & Hirsch (2010), the CEE region has experienced considerable shifts in the ownership structure of forests since 1990, due to restitution and privatization processes. Yet it is also important to differentiate and

consider the specific development of each country before the current transition period. Former nationalized forest areas have been returned to the original owners, or the respective heirs, or state-owned forest land has been privatized. In some cases both processes have taken place (Schmithuesen & Hirsch 2010). This means that in some countries the private forest sector is relatively young, with further changes in ownership patterns to be expected (Hirsch et al. 2007). The four EU member states included in this study still exhibit either dominant (CZ, RO, PL) or with around 50% even (SK) public ownership of forests (Hirsch et al. 2007). Private ownership is mainly characterized by fragmentation, as small-scale properties prevail (Schmithuesen & Hirsch 2010).

The forest area in Europe itself is expanding especially in Belarus, Poland, Slovakia, and Ukraine as a result of afforestations due to soil preservation or land-use changes (Szczygiel et al. 2009). But the actual shifts in land tenure and ownership as well as the resulting fragmentation cause a neglect of management efforts (FAO 2007). Concerning wildfires this is especially relevant, as forest management also implies fuel management. According to Xanthopoulos et al. (2006), a great variety of management options exist as practices depend on local topographic, ecologic and socio-economic characteristics. The options range from horizontal isolation of fuels through firebreaks, fuel reduction through physical removal or prescribed burning to breaking the vertical continuity of fuels through pruning of trees. While the construction of firebreaks has always been a prominent measure and fuelbreaks have become common during the last decades, the use of prescribed burning is still very limited. Fire bans, complex land-use structures, scarce professional experience, and negative public perception interfere with its implementation in most countries (Xanthopoulos et al. 2006). The fact

that exclusion of fire invariably leads to fuel accumulation and thus, to an increased intensity of fires has been named the paradox of wildland fire (Brown & Arno 1991). But apart from reducing forest fuels, it is also increasingly recognised that fire can be utilised as a management tool to substitute traditional land-use systems and burning practices. It can promote natural reforestation of fire-adapted species or improve natural wildlife habitats (Goldammer & Bruce 2005, FAO 2006a, Lázaro et al. 2008). Since a general abandonment of rural fire practices has taken place in Central Europe and the Baltic countries, prescribed burning nowadays plays an important reviving role in these cultural landscapes (Lázaro et al. 2008).

3.4 Policy and Legal Frameworks

Economic transition, weakened governance and decreased fire management capabilities have led to an increase of uncontrolled forest use and wildfires in Eastern Europe (FAO 2007, Goldammer 2011). Unclear institutional responsibilities and inconsistent policies and legislation complicate fire management (FAO 2007), while restitution and privatization of forests result in inadequate forest and fuel management on small-scale and fragmented forest estates (Vuletic et al. 2010, Goldammer 2011). As most of the CEE countries have enacted new forest legislation relatively hastily after the first political changes (Cirelli 1999), it needed to be patched up over time. By 2002, many countries have reviewed the existing legislation already two times and were about to implement the second forest law after 1990 (Fredriksson 2003). Apart from changes in land tenure and market economy, either approach or actual accession to the EU have been reasons for innovations of forest policies and legislation in Eastern Europe (Fredriksson 2003). Nevertheless it has to be stressed that at that time the EU mainly regulated forestry subsidy

programmes which have only been seen as one aspect of rural development (Cirelli 1999). Especially the involvement of multiple stakeholders, like civil society and Non-Governmental Organisations (NGOs) in decision-making processes has been characteristic for the second generation of forest and environmental policies (Fredriksson 2003). According to a study by Cirelli (1999), the growing participation of different stakeholders increases public support for administrative actions. Spreading knowledge of legislation and appropriate management in forests is thus beneficial for law enforcement, particularly because the respective officials are usually not equipped with strong powers. Furthermore, achieving a reduction of state involvement in forestry has been necessary to overcome inflated and inefficient structures of state-owned enterprises, and strengthen the private sector.

Nowadays, the EU has grown in importance as a policy-making institution within the overall forest policy framework (Schmithuesen & Hirsch 2010). It can identify policy priorities in the field of forest fires and, more specifically, provide financial assistance to wildfire-related activities (Morgera & Cirelli 2009). These measures and instruments are also relevant for candidate members or otherwise associated countries. One example is the common information system EFFIS (JRC 2009). All EU programmes aiming specifically at forest fires from 1988 until today have been listed by FOREST EUROPE (2010):

1. Community Forest Action Programme (1988-1992)
2. Forest Fire regulation 2158/92 (1992-2002)
3. Forest Focus 2152/2003 (2003-2006)
4. Life+ Regulation 617/2007 (2007-2013)

Further instruments related to forest fires are the Rural Development Regulation 1698/2005, regional policies (INTERREG programmes) and

research programmes. Other more recent actions by EU institutions include the Commission's communication on a community approach on the prevention of natural and man-made disasters (EC 2009a); the White Paper on adapting to climate change (EC 2009b); the Green Paper on forest protection and information (EC 2010); the Council's conclusions on prevention of forest fires within the EU (EU Council 2010); and the Biodiversity Strategy to 2020 (EC 2011). Although forest fires have been on the political agenda for more than 20 years in the EU, the main issues are still dealt with in

national policies by the member states (Montiel & San-Miguel 2009). As indicated above, the EU exerts its major influence on prevention legislation or programmes for rural development and disaster management. For this, the National Forest Plans and Wildfire Defence and Protection Plans are the main planning documents (Montiel & San-Miguel 2009). Research on wildfires has also been active in Europe for over two decades now. This is especially due to EU funded projects within its Framework Programmes, for example the "Fire Paradox" research (Biro 2009).

4 Comparative Analysis of Questionnaire Results

The questionnaire has been sent to individual forest fire experts in CEE and in the end, six completed forms have been received. The results of the questionnaire are meant to further extend the results presented in chapter 3. Owing to their standardized nature, the answers are arranged to enable a comparative analysis of the four categories. Participating are experts from national forest research institutes, universities and ministries listed in appendix 1.

4.1 Fire Situation

In CEE the usual size of forest fires does not exceed 10 ha in most cases (Tab. 1). In BY, CZ and PL the commonly burnt area is even below one hectare. The largest average size is around five hectare in Romania according to the local expert.

Forest fires are mainly anthropogenically triggered (87% - 99%) in all of the countries (Tab. 2). The Czech Republic has the lowest share of human-caused fires with 87%. But it has to be noted that the Czech figures were only valid for state forests representing around 50% of the total forest area. Belarus reports an

increase during the last 10 years, especially through fires caused by agricultural land-use.

Of all the human causes for forest fires, carelessness in fire handling is the most common reason (Tab. 3). Romania is the only exception where fire spread from land clearance is more significant, a cause that is also noted by the experts in SK and UA. In this context Ukraine is a special case as all the fire causes are marked as significant. Poland is the only country to specifically report intentional fires, especially arson as another main cause for forest fires.

In detail, unattended campfires and discarded cigarettes are a common cause in Belarus. The Czech expert stresses that especially visitors in the forests caused 75% of the fires. In Poland, carelessness accounts for 38% and arson for 45% of forest fires. The spread of fires to forests in Romania is mainly due to the uncontrolled ignition of dried harvest residues on agricultural lands. In Slovakia carelessness is exceptionally present with 86.5%. In the case of Ukraine the expert also names unattended campfires as an example for carelessness along with harvesting operations by private contractors. Arsonists are present especially in areas with land tenure conflicts.

Table 1. [Question 2.1] - “What is the most characteristic size of a forest fire in your country?”

| Size | BY | CZ | PL | RO | SK | UA |
|------------|----|----|----|----|----|----|
| < 1 ha | x | x | x | - | - | - |
| 1 - 10 ha | - | - | - | x | x | x |
| 10 - 50 ha | - | - | - | - | - | - |
| > 50 ha | - | - | - | - | - | - |

Table 2. [Question 2.2] - “What is the share of human and natural induced forest fires, respectively, in your country?”

| Fire causes (%) | BY | CZ | PL | RO | SK | UA |
|------------------|----|----|----|----|----|----|
| Human causes | 95 | 87 | 99 | 95 | 99 | 98 |
| Natural causes | - | 13 | 1 | 5 | 1 | 2 |
| (Unknown causes) | 5 | 0 | 16 | 35 | 8 | 2 |

Table 3. [Question 2.3] - “Which of the following would you consider the most significant cause(s) of human-induced forest fires in your country?”

| Human fire causes | BY | CZ | PL | RO | SK | UA |
|---------------------------------|----|----|----|----|----|----|
| Carelessness | | x | x | x | - | x |
| Accidental ignition | | - | - | - | - | x |
| Fire spread from land clearance | | - | - | - | x | x |
| Intentional fires | | - | - | x | - | x |

Table 4. [Question 2.4] - What is the impact of forest fires on different stakeholder groups in your country?

| Stakeholder groups | BY | CZ | PL | RO | SK | UA |
|--------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| General public | Barely relevant | Not relevant | Rather relevant | Rather relevant | Very relevant | Rather relevant |
| Rural communities | Cannot judge | Not relevant | Rather relevant | Very relevant | Rather relevant | Very relevant |
| Forest owners | Cannot judge | Barely relevant | Rather relevant | Very relevant | Barely relevant | Very relevant |
| Forest industries | Cannot judge | Barely relevant | Rather relevant | Rather relevant | Barely relevant | Not relevant |
| Others... | - | - | - | Very relevant | - | - |

Concerning the impact of forest fires on different stakeholders, the results show no clear tendency for any specific group (Tab. 4). Only forest industries seem not to be heavily impacted. In Belarus, this is due to the lack of private forests. The problem for the general public has been the smoke caused by large wildfires in recent years. The Romanian expert is the only one to name an additional stakeholder group: water managers. In montane areas and especially in the Carpathians, forest fires are difficult to control and increase also the risk of erosion and landslides. Management for watershed conservation is done on almost half of the total forest area. As the Ukrainian forests are almost exclusively state owned, national ministries and agencies as the actual managing institutions are also the most strongly affected “forest owners”. The timber or forest industry does not own forests and is thus not eminently affected. As the largest threat for all stakeholders the expert identifies wildfires in the radioactively contaminated zones close to the Belarussian border (300 000 ha) caused by the Chernobyl disaster in 1986.

4.2 Natural Preconditions and Trends

The main areas with high fire risk are consistently characterised as being composed of forests of coniferous species, mostly *Pinus sylvestris* (Tab. 5). The experts also remark that especially young stands are affected. Mixed forests of deciduous and coniferous species are affected only in PL and SK. Pure broadleaved forests appear to carry a higher risk in Romania. Forest areas in lowland altitudinal zones are characteristic for BY, CZ, PL, and UA. Concerning management type it is high forests that include the majority of areas with high fire risk, with the exception of Romania. The importance of natural disturbances like storms and bark beetles for the occurrence of forest fires is emphasised for Slovakia.

While the picture does not change significantly for the near future in most countries (Tab. 6), the Ukrainian expert expects more fire incidents in the intermediate montane area (Carpathians) and the northern part of the country. This will affect especially *Picea abies* as well as additional deciduous species (e.g. *Fagus sylvatica*). In Belarus, the focus will shift even more to the radioactively contaminated zones (1.96 million ha) where fuels will further accumulate.

After evaluating a diagram of recent forest fire statistics (see chapter 3.1), the experts are asked to estimate the future trends of burnt area and number of fires separately for their respective countries (Tab. 7). However, no estimations are given for forest fire trends in Belarus.

Concerning burnt area, the other countries in the eastern part of the study area (RO, UA) expect either an increase or strong increase in the near future. CZ, PL and SK see a decrease or constant progression at least. Still, the Belarussian expert considers past trends and states that during the last few years the burnt area has been decreased due to more modern equipment of fire fighting services and successful early detection. The decrease in the Czech Republic is due to reduced burning of harvesting residues on clearcut areas, although the influence of changing climatic conditions has yet to be determined. In Poland, the conversion of coniferous monocultures into mixed stands, as well as further developments in early detection and fire management are supposed to decrease the burnt area. The increase in Romania is expected to be due to lower precipitation rates and rising mean temperatures. Socio-economic factors like fragmentation of private forests and agricultural burnings also play an important role. The Slovakian expert expects the efforts of implementing fire forecasts to be successful which might possibly lead to a stabilisation of the annually burnt area. In Ukraine especially the share of large fires is expected to increase.

Table 5. [Question 3.1] – “How would you describe the main forest areas with high fire risk at present according to the 4 characteristics (a-d) listed below?”

| Characteristics | BY | CZ | PL | RO | SK | UA |
|---------------------|-------------------------|--|--|---|---|-------------------------------|
| a) Altitudinal zone | Lowland + Colline | Lowland + Colline | Lowland | Montane | Int. montane + Up. montane | Lowland + Int. montane |
| b) Management type | High forests | High forests | High forests | Coppice with standards | High forests | High forests |
| c) Forest type | Coniferous forests | Coniferous forests | Coniferous forests + Mixed forests | Broadleaved forests + Coniferous forests | Coniferous forests + Mixed forests | Coniferous forests |
| d) Typical species | Pinus sylvestris | P. sylvestris, P. nigra, Picea abies | P. sylvestris, P. abies, Larix decidua, Betula spp. | P. abies, Abies alba, P. sylvestris, Fagus sylvatica, Quercus petraea | P. abies, P. sylvestris, A. alba, F. sylvatica | P. sylvestris, Betula spp. |

Table 6. [Question 3.2] – “How would you picture the situation in ~10 years according to the same criteria? (See Question 3.1)”

| Characteristics | BY | CZ | PL | RO | SK | UA |
|---------------------|-------------------------|---|--|--|---|---|
| a) Altitudinal zone | Lowland + Colline | Lowland + Colline | Lowland | Montane | Int. montane + Up. montane | Intermediate montane |
| b) Management type | High forests | High forests | High forests | Coppice with standards | High forests | High forests + Coppice with standards |
| c) Forest type | Coniferous forests | Coniferous forests | Coniferous forests + Mixed forests | Broadleaved forests + Coniferous forests | Coniferous forests + Mixed forests | Coniferous forests + Mixed forests |
| d) Typical species | P. sylvestris | P. sylvestris, P. nigra, P. abies | P. sylvestris, P. abies, L. decidua, Betula spec. | P. abies, A. alba, P. sylvestris, F. sylvatica, Q. petraea | P. abies, P. sylvestris, F. sylvatica | P. sylvestris, P. abies, Betula spp., F. sylvatica |

For the number of forest fires, all countries except CZ expect an increase. The reasons for the decrease in the Czech Republic are the changes in the treatment of clearcut areas mentioned above. PL and RO expect an increase due to changes in temperature and precipitation patterns. In Slovakia determining factors are the possible impacts of climate change in connection with the likely spreading of bark beetles in areas damaged by a storm back in 2004.

Subsequently the experts are asked to rate natural factors by their importance as drivers for wildfire regimes. To date, especially precipitation exerts major influence on wildfire regimes in the study region followed by temperature (Tab. 8). The other factors (wind, fuel quality and fuel load) receive a considerably lower average rating. The Slovakian expert stresses the importance of meteorological factors (precipitation, temperature, wind) and remarks that the currently low importance of fuel factors is partly due to insufficient consideration in research.

For the situation in the near future the fuel factors gain higher recognition from the experts, ranging closer to temperature (Tab. 9). Still, precipitation receives the highest rating. The importance of fuel load is emphasised for Belarus especially in the contaminated zones close to the Ukrainian border, where no management has been conducted since 1986. A clear importance of precipitation followed by fuel quality is visible for the Czech Republic, while in PL and RO precipitation and temperature are emphasised. In Ukraine, precipitation and wind receive a high rating already for present fire regimes, which will be supplemented by fuel load in the future. This is again owing to the further build-up of fuels in the contaminated zones.

4.3 Forest Management

According to most experts' opinions, the future trend of wildfires is expected to have no influence on the supply of forest biomass (Tab. 10; question 4.1), except for Slovakia where a negative impact is foreseen. An assessment from Belarus is not provided. In the Czech Republic, the fact that most forest fires appear only on clear cutting areas provides no threat to the actual supply of timber or biomass in general. The expected diametrical development of burnt areas (decrease) and the number of forest fires (increase) in Poland leads to the same conclusion. For RO and UA the relatively young age of forests affected by fires is given as the reason for the low influence of wildfires.

The integration of forest fire risks and forest fire prevention in forest management and planning is described as strong by PL, RO and UA while it is seen as very weak in CZ and SK (Tab. 10; question 4.2). For Belarus the expert assesses integration as non-existent but provides the information that national forest fire regulations based on fire risk zoning exist. In the Czech Republic, forest fire prevention is focussed more on legislative measures and restricting the use of fire for leisure and working activities in the forest. The reason for the very weak integration in Slovakia is due to the fact that neither fire susceptibility nor risk reduction are taken into account for the species composition of forests. In Poland, forest management and forest fire risks are strongly interconnected to reduce fire susceptibility. An efficient cooperation between forest agencies and official institutions is the reason for the strong integration in Romania, while in Ukraine forest fire prevention methods have traditionally been an important part of forest management.

The use of fire as a management tool in forests is only allowed in CZ and PL (Tab. 10; question 4.3). Still its use in the Czech Republic is

restricted to the burning of harvest residues on clearcut areas while in fact prescribed fires to reduce forest fuels are not allowed. In Poland, it can be used in justified cases but this has rarely been applied and then mainly for sanitary purposes to mitigate pest outbreaks. Romania is a special case, as prescribed burning is not allowed in forests but applied in the Danube delta to burn dry reed. In BY, SK and UA the use of fire is not allowed in forests but in the latter case it can be authorised for experimental purposes.

4.4 Forest Management

Analogous to the rating of natural factors, the experts are asked to rate socio-economic factors in question 5.1. As can be seen by the average values, rural abandonment is identified as the most common socio-economic driver for present wildfire regimes (Tab. 11). Administrative reforms and restitution processes range close behind while privatization receives the lowest rating on average. In Belarus privatization and restitution do not play an important role as all forest ware state owned. Rural abandonment is a prominent factor in the rating of the Czech expert although it is placed at a comparatively low level. In Romanian restitution is the most important factor, causing severe fragmentation

of forests. Furthermore, the expert also adds a recent legislative initiative for agricultural subsidies with high importance to the predefined list. In order to receive financial benefits, agricultural land owners are obliged to clear their fields for planting preparations. In many cases this leads to a spreading of fires to nearby forests. For Slovakian conditions none of the available factors receive a high rating. The expert rather mentions local communities in one of the country's national parks and their generally careless use of fire. Further factors are the accessibility of forests in the Carpathian Mountains and tourism. In Ukraine, administrative reforms and rural abandonment are identified as most important drivers for present wildfire regimes with privatization in a middle position.

This rating does not change for the future situation (Tab. 12). Privatization and restitution are expected to be important factors in Poland, especially in the future. According to the expert, rural abandonment can possibly be reversed by urban citizens returning to the countryside. Although it is not expected to exceed moderate levels, privatization in Ukrainian forests can gain more importance in the future, while a legal basis for restitution does not actually exist.

Table 7. [Questions 3.4 & 3.5] – “In comparison to the present situation, how would you estimate the overall future trend for burnt area / number of fires in ~10 years for your country?”

| | BY | CZ | PL | RO | SK | UA |
|----------------------|-----------------|----------|----------|----------|----------------------|-----------------|
| 3.4: Burnt area | I cannot answer | Decrease | Decrease | Increase | Constant progression | Strong increase |
| 3.5: Number of fires | I cannot answer | Decrease | Increase | Increase | Increase | Increase |

Table 8. [Question 3.6.1] – “Please rank the following natural factors by their importance as drivers for the present wildfire regimes in fire prone areas. (From 1 - low to 5 - high).”

| Natural factors | BY | CZ | PL | RO | SK | UA | Average |
|-----------------|----|----|----|----|----|----|---------|
| Precipitation | 5 | 5 | 5 | 5 | 4 | 5 | 4,8 |
| Temperature | 5 | 2 | 4 | 5 | 4 | 3 | 3,8 |
| Wind | 4 | 3 | 1 | 5 | 2 | 4 | 3,2 |
| Fuel quality | 5 | 4 | 3 | 4 | 1 | 3 | 3,3 |
| Fuel load | 5 | 3 | 2 | 4 | 1 | 3 | 3,0 |

Table 9. [Question 3.6.2] – “Please rank the following natural factors by their importance as drivers for the estimated future wildfire regimes in fire prone areas. (From 1 - low to 5 - high).”

| Natural factors | BY | CZ | PL | RO | SK | UA | Average |
|-----------------|----|----|----|----|----|----|---------|
| Precipitation | 5 | 5 | 5 | 5 | 5 | 5 | 5,0 |
| Temperature | 5 | 2 | 4 | 5 | 5 | 4 | 4,2 |
| Wind | 4 | 3 | 1 | 5 | 5 | 5 | 3,8 |
| Fuel quality | 5 | 4 | 3 | 4 | 5 | 4 | 4,2 |
| Fuel load | 5 | 3 | 2 | 4 | 5 | 5 | 4,0 |

Table 10. [Question 4.1] – “What kind of influence will the future trend of wildfires have on the forest biomass supply?”

[Question 4.2] – “How would you describe the integration of forest fire risks and prevention in forest management and planning?”

[Question 4.3] – “Is the use of fires a management option allowed in your country?”

| | BY | CZ | PL | RO | SK | UA |
|--|---------------------------------|--------------|--------------|--------------|-----------|--------------|
| 4.1: Future wildfires & biomass supply | I cannot answer | No influence | No influence | No influence | Negative | No influence |
| 4.2: Integration in forest management | No integr./consideration at all | Very weak | Strong | Strong | Very weak | Strong |
| 4.3: Fire as a management option | No | Yes | Yes | No | No | No |

Table 11. [Question 5.1.1] – “Please rank the following socio-economic factors by their importance as drivers for the present wildfire regimes in fire prone areas. (From 1 - low to 5 - high).”

| Socio-economic factors | BY | CZ | PL | RO | SK | UA | Average |
|-------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|----------------|
| Administrative reforms | 5 | 1 | 1 | 2 | 1 | 5 | 2,5 |
| Privatization | 1 | 1 | 5 | 1 | 1 | 3 | 2,0 |
| Restitution | 1 | 1 | 4 | 5 | 2 | 1 | 2,3 |
| Rural abandonment | 1 | 3 | 3 | 3 | 2 | 5 | 2,8 |
| Others... | - | - | - | 5 | - | - | |

Table 12. [Question 5.1.2] – “Please rank the following socio-economic factors by their importance as drivers for the estimated future wildfire regimes in fire prone areas. (From 1 - low to 5 - high).”

| Socio-economic factors | BY | CZ | PL | RO | SK | UA | Average |
|-------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|----------------|
| Administrative reforms | 5 | 1 | 1 | 2 | 1 | 5 | 2,5 |
| Privatization | 1 | 1 | 5 | 1 | 1 | 4 | 2,2 |
| Restitution | 1 | 1 | 4 | 5 | 2 | 1 | 2,3 |
| Rural abandonment | 1 | 3 | 3 | 3 | 2 | 4 | 2,7 |
| Others... | - | - | - | 5 | - | - | |

The integration of forest fire risks and forest fire prevention in forest policy-making is described as strong to very strong by CZ, PL and RO while it is seen as very weak in SK and UA (Tab. 13; question 5.2). For Belarus the expert assesses the integration as non-existent and reduces the obligations of forest policy to the setting of financial means for fire protection. Apart from the very strong integration in policy-making the Czech expert stresses the strong affinity of existing legal documents towards fire prevention. For Slovakia on the other hand it is stated by the expert that results of a fire protection project were only partly included into forestry legislation. The project is conducted in a storm damaged forest area in the Carpathians and elaborates local fire management plans. The negative assessment in the case of Ukraine is due to the non-existent process of forest policy-making.

The farsightedness of wildfire policies is assessed as long-term (more than five years) for

BY, CZ, PL, and RO (Tab. 13; question 5.3). In accordance to the argument mentioned in the previous paragraph, the expert rates wildfire policies as non-existent for Ukraine, while it is described as short-term and with limited significance for Slovakia. In Belarus, fire prevention projects even span 20 years according to the expert.

Decision-making processes in wildfire management are open to multiple stakeholders in CZ, PL, RO, and SK, while they are described as non-existent for BY and UA (Tab. 13; question 5.4). In Poland, forest management plans including fire management measures are accessible to the public. Whereas in Romania the participation is more restricted to the respective forestry and fire fighting agencies. The involvement of multiple stakeholders in Slovakia has been introduced during the elaboration of the previously mentioned fire management plans.

International guidelines for fire management are employed by BY, PL and RO in development and implementation of national legislation (Tab. 13; question 5.5). In the Czech Republic, which uses its own guidelines, and in Ukraine this is not the case. Similar procedures do not exist in Slovakia. The Polish expert explicitly names FAO as well as the two forest certification schemes Forest Stewardship Council and the Programme for the Endorsement of Forest Certification schemes, which have introduced certain standards in the field of forest fires. In Romania, the experiences and knowledge gained from forest fire research in France are incorporated into national legislative norms.

Fire management plans exist in all countries at the forest district level, while in the Czech Republic they also cover the county and, analogous to Belarus, the national level (Tab. 14). Different from state forests, privately owned plots in Poland are subjected to a simplified management plan which also includes fire protection measures. In Slovakia, fire management plans are only produced for the project area in the Carpathians, spanning state as well as private forests. In Ukraine, fire management plans only exist in state owned forests.

Preventive measures are in all cases included in afore-mentioned fire management plans (Tab. 15; question 5.7). In Belarus, these actions are implemented annually and also in Romania several measures are considered as normally recurring tasks not necessarily being included in the actual fire management plan. On the other hand, in Slovakia preventive measures occur only in the fire management plans that are set up for said storm damaged forest area in the Carpathians.

Concerning non state-owned forests, fire prevention measures are only subsidized or otherwise supported in CZ and RO (Tab. 15;

question 5.8). That is not the case in PL, SK and UA, while in BY it is due to the non-existence of private forests. The Czech expert states that airborne fire monitoring and forest roads are among the supported measures for private forest owners. A different case is presented for Romania, where private forests still fall under the responsibility of state-owned forest enterprises. In Poland, private forest owners are eligible to receive subsidies for silvicultural measures which do not directly relate to fire prevention. Also in Slovakia preventive measures have to be financed by the individual owners; only the creation of before mentioned fire management plans has been supported by an environmental foundation. According to the Ukrainian expert, wildfire prevention measures are only applied in state forest and not considered in the other 30% of the forested area.

As a concluding task, the experts are asked to assess the efficiency of existing measures in controlling the wildfire situation (Tab. 16). General legislative measures are rated as efficient to very efficient for most countries except Ukraine, where they are seen as being less efficient. An overall average rating for the whole study region as efficient can be ascribed. An even better value is derived for general public information measures which are seen as efficient to very efficient in all countries. Information for qualified personnel is also rated as efficient on an average basis with exception for Ukraine. There the option is assessed as being not applicable. With a balanced rating between efficient and less efficient, information measures especially for private forest owners can altogether be described as being slightly efficient. The absence of private forest owners in wildfire issues makes the option not applicable in BY and UA. General economic incentives receive a very distinguished rating throughout the region. They are considered to be (very) efficient in BY and SK, less efficient in CZ and PL, and not efficient in Romania. For Ukrainian

conditions the option is again viewed as not applicable. The overall result is the lowest average rating of all measures included in this question. The next option (cooperation between responsible agencies) is again regarded as efficient to very efficient in most countries except for Ukraine, where it is assessed as not

efficient. Altogether, it can be seen as an efficient measure similar to the last one (informal exchange between agencies). Here, the ratings are again very distinguished, including efficient to very efficient for BY, CZ and SK, and less to not efficient for RO and UA. The respective situation in Poland cannot be judged by the expert.

Table 13. [Question 5.2] – “How would you describe the integration of forest fire risks and prevention in forest policy making?”

[Question 5.3] – “How would you assess the farsightedness of wildfire policies in your country?”

[Question 5.4] – “Are decision-making processes in wildfire management open to the participation of multiple stakeholders?”

[Question 5.5] – “Are any international guidelines for (forest) fire management used to develop and implement national or local legislation?”

| | BY | CZ | PL | RO | SK | UA |
|---|---------------------------------|-------------|-----------|-----------|---------------------|---------------------|
| 5.2: Integration in forest policy-making | No integr./consideration at all | Very strong | Strong | Strong | Very weak | Very weak |
| 5.3: Farsightedness of wildfire policies | Long-term | Long-term | Long-term | Long-term | Short-term | Do not exist at all |
| 5.4: Open decision-making processes | Do not exist at all | Yes | Yes | Yes | Yes | Do not exist at all |
| 5.5: International guidelines for local legislation | Yes | No | Yes | Yes | Do not exist at all | No |

Table 14. [Question 5.6] – “At which levels do forest fire management plans exist?”

| Administrative level | BY | CZ | PL | RO | SK | UA |
|----------------------|----|----|----|----|-----|-----|
| National | x | x | - | - | - | - |
| County | - | x | - | - | - | - |
| Forest district | x | x | x | x | (x) | (x) |

Table 15. [Question 5.7] – “If fire management plans exist, do they include fire prevention measures?”

[Question 5.8] – “Are the measures specified in question 5.7 subsidized or otherwise supported by the government for private forests or other ownership types?”

| | BY | CZ | PL | RO | SK | UA |
|--|-----|-----|-----|-----|-----|-----|
| 5.7: Fire prevention measures included | Yes | Yes | Yes | Yes | Yes | Yes |
| 5.8: Subsidisation for private forest owners | - | Yes | No | Yes | No | No |

Table 16. [Question 5.9] – “How efficient are the measures in place to control the wildfire situation in your country?”

| Control measures | BY | CZ | PL | RO | SK | UA |
|--|----------------|----------------|----------------|----------------|----------------|----------------|
| Legislation | Very efficient | Very efficient | Efficient | Very efficient | Efficient | Less efficient |
| Information for the public | Very efficient | Efficient | Efficient | Very efficient | Very efficient | Efficient |
| Information for qualified personnel | Very efficient | Efficient | Efficient | Efficient | Very efficient | Not applicable |
| Information for private forest owners | Not applicable | Efficient | Less efficient | Less efficient | Efficient | Not applicable |
| Economic incentives | Very efficient | Less efficient | Less efficient | Not efficient | Efficient | Not applicable |
| Cooperation between responsible agencies | Very efficient | Very efficient | Efficient | Very efficient | Very efficient | Not efficient |
| Informal exchange between agencies | Very efficient | Efficient | Cannot judge | Less efficient | Efficient | Not efficient |

5 Discussion

The corresponding questionnaire results are discussed for each of the five hypotheses and set into perspective by additional comments from the forest fire experts and relevant findings of the literature research. The analysis is further supported by taking into account the underlying causes and effects of the Russian wildfires during summer 2010, which serve as relevant exemplary cases for the study region.

Hypothesis I:

“Due to the increase of average burnt area and number of wildfires, their active management will become an even greater aspect of the sustainable use of forests in CEE.”

In the questionnaire, the experts see no significant changes of fire regimes for the near future concerning either altitudinal zones or affected species (Tab. 6). But the expert for Ukraine stresses the higher exposure of forests in the Carpathian Mountains to fire risk. It has to be considered that this development can also be

relevant for the ranges in PL, RO and SK. Still, a general increase of burnt area is acknowledged for RO and UA (Tab 7; question 3.4). This, and the decrease or constant progression for BY, CZ, PL, and SK is also backed up by the compiled fire statistics (Fig. 11). Yet it is important to consider the proportion of burnt area with reference to each country’s overall forest area. Within the specific timeframe of 2000 to 2009, the proportion of average annually burnt area does not exceed 0.1% of the overall forested area in any of the countries. From the survey comments it becomes clear that on the one side the conversion of coniferous forests, along with more sophisticated fire fighting and forecasting techniques, and on the other side climate change are expected to have the largest impact on future forest fire situations.

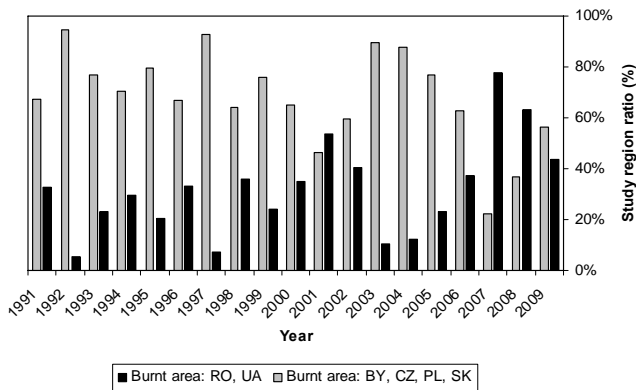


Figure 11. Development of burnt area in the study region from 1991 to 2009. Countries that reported a future increase (RO, UA – black columns) were dissociated from the others (BY, CZ, PL, SK – gray columns). The values for each group were computed against the region’s total annually burnt area.

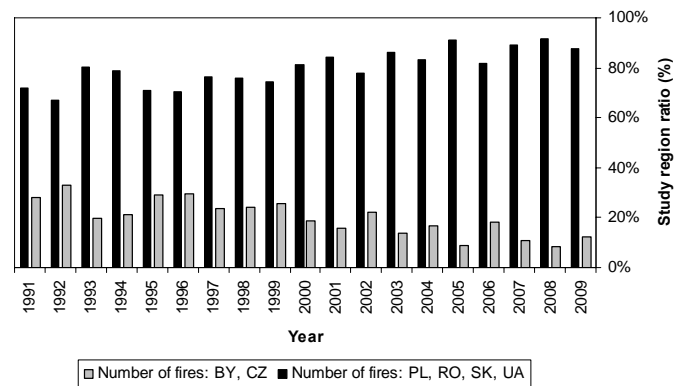


Figure 12. Development of number of fires in the study region from 1991 to 2009. Countries that reported a future increase (PL, RO, SK, UA – black columns) were dissociated from the others (BY, CZ – gray columns). The values for each group were computed against the region’s total annual number of fires.

Analogous to the procedure for burnt area, the decrease in BY and CZ can be supported by fire statistics from 1991 to 2009, as is the increase for PL, RO, SK, and UA (Fig. 12). Opposed to the partly increasing fire incidents most experts see no effect on the supply of forest biomass (Tab. 10; question 4.1). But they also state that especially young coniferous forests are afflicted due to dense planting schemes and high concentration of burnable fuels. The lost potential of these young stands is difficult to assess. The relatively low figures of burnt area and number of fires in CZ and SK can be a reason why the integration of forest fire risks and prevention in forest management is seen as very weak (Tab 10; question 4.2). It has also to be considered that within the study region these two countries hold a relatively small forest area.

The growing number of fires is expected to be particularly caused by higher ignition probabilities, which themselves will be due to ‘positive’ fire weather conditions, e.g. the expected reduction of precipitation and rise of mean temperatures. The experts’ opinion on these developments is consistent with the findings of the literature research. Apart from the importance of meteorological factors fire fuels are identified as an important issue for future fire regimes (Tab. 9; question 3.6). The radioactively contaminated zones in Belarus and Ukraine are an illustrative example of how absent management can lead to fuel build-up. Another instance is the storm damaged region in Slovakia. And although these are extreme cases, fuels are the point where forest management becomes decisive. Fuel load can either be actively influenced by tending and harvesting operations or prescribed burning. Although Poland is the only country where this measure is actually allowed (Tab. 10; question 4.3). But it can be expected that prescribed burning will play a much more important role in the future, if legislation and regulations are accordingly adapted. The reduction of carbon dioxide emissions can be a crucial argument in achieving those changes. In Europe, annual emissions from wildfires amount to approximately 11 million tons of CO₂ over a 5-year period (Rego et al.

2010). With efficient prescribed burning measures in place this figure can be reduced to almost 6 million tons (Rego et al. 2010). And it has to be taken into account that parts of the carbon emissions are subsequently sequestered again by regrowing plants (FAO 2007), which is another essential aspect of forest management. With regard to climate change as a driver of forest fires it is important to point out that the understanding of adaptive capacities and vulnerability of forests in Europe still requires more research efforts. This is especially the case when considering regional scales such as the Carpathian mountain ranges (Lindner et al. 2010). Increasing temperatures do not necessarily imply a greater disturbance by wildfires (Flannigan et al. 1998). But nevertheless, it has been outlined early by Goldammer (1996) and Stocks et al. (1998) that fire activity in Russian boreal forests will rise within the following years due to both climate change and budget constraints of fire fighting services. Projections by Malevsky-Malevich et al. (2008) show a doubling of the area of maximum fire danger risk by the middle and a definite increase of fire danger for Russia by the end of the 21st century. Therefore it has also to be considered as an indication of the future importance of fire management. Forest fires have already been classified as a threat to biodiversity for Eastern Europe in the latest assessment of Europe's environment (EEA 2007).

Hypothesis II:

“Changing forest ownership structures and land fragmentation due to restitution and privatization in CEE affect present and future fire regimes.”

Based on the results of the questionnaire and the literature review, it can be said that on the whole neither restitution nor privatization processes are as significant for fire regimes as rural abandonment (Tab. 11 & 12). Nevertheless,

restitution is ascribed a higher importance than privatization, particularly as the latter is not a very relevant topic for Belarus. For the present, administrative reforms rank highest in this former Soviet republic but at one time or another privatization can become a part of these measures.

Despite changing ownership structures, binding fire management plans exist on the forest district level (Tab. 14). These also include fire prevention measures (Tab. 15; question 5.7), except for Ukraine where those measures are only applied in state forests (Tab. 15; question 5.8). Yet, actual fire prevention is only supported for non-state forests in CZ and RO although these financial incentives have not been assessed as efficient (Tab. 16). Missing financial support inhibits or even prevents private forest owners in the other countries from taking steps towards fire prevention within their own forests. Fragmented properties further enhance this effect. This is especially the case in PL and RO, where private ownership is very scattered and private owners are less experienced in forest management, as is stated in the questionnaires. However, at least for Poland the establishment of forest owner associations and developing relations of families to their forests are expected to have a positive impact on management efforts.

The breakdown of socialistic systems has been the starting point for structural changes of property and use rights in CEE (Vuletic et al. 2010) and, for example in Poland, they are further influenced by accession to the EU in 2004 (Schmithuesen & Hirsch 2010). These changes continue to complicate forest management and thus, fire prevention. For the 2010 wildfire episodes in Russia neglected fuel management along with rural abandonment were also two of the most important factors according to Goldammer (2010).

Hypothesis III:

“Policies and law enforcement measures by official agencies in CEE are insufficient to control human influence on forest fire regimes.”

Human-caused fires prevail in CEE. Carelessness in dealing with campfires or cigarettes by forest visitors is a very common cause (Tab. 3). Ranging closely behind these ‘recreational’ matters is fire spread from land-clearance. Intentional fires are also identified as a problem, for example in Poland. A rising number of fires (Fig. 12) can be an indication of weak governance caused by misdirected administrative reforms. These are recognised as important factors by BY and UA (Tab. 11 & 12). But although a reduction of personnel and insufficient funding for fire protection might be a fundamental reason for the rising number of fires in Ukraine, a reverse development is shown for Belarus.

Preceding any reforming measures are the objectives of (forest or environmental) policies. The ability to integrate forest fire prevention into these objectives is assessed negatively by SK and UA but with different backgrounds (Tab. 13; question 5.2). While forest fires seem not to be a pressing issue in policy-making in Slovakia, the actual progress in advancing legal regulations appears to be very slow in Ukraine. This is also reflected by the assessment of the farsightedness of wildfire policies (Tab. 13; question 5.3). Another factor describing the flexibility of policies is the participation of different stakeholders in decision-making processes. This is also non-existent in Ukraine and Belarus, where old hierarchical structures seem to dissolve slowly (Tab. 13; question 5.4). The overall efficiency of legislative measures is assessed as less efficient by the Ukrainian expert (Tab. 16), which does not surprise given the information above. Yet, for all the other countries these measures are efficient to very efficient which might be connected to the last two points in the list (cooperation and exchange

between different agencies). Those are also seen as quite efficient except for Ukraine. When considering that the number of fires in three of these countries (PL, RO, SK) is on the rise, the impression is created that policy and legal measures might be stretched to their limits. The allegedly efficient implementation is contradicted by their seemingly ineffectiveness.

Human activities outrank natural factors as a source of ignition by far and directly determine the number of wildfires (Goldammer & Crutzen 1993, Silva & Harrison 2010). Because of that it is essential to consider the human influence on fire regimes in planning and setting up of institutional and policy frameworks. These are prerequisites for strategic planning and implementing fire management (FAO 2006b). However, in some countries like Slovakia forestry contributes a small fraction to the national economy and is thus only perceived as a minor issue in policy-making (Sulek 2002). And although wildfire prevention measures contribute to the avoidance of emergency situations and expensive fire suppression, they are slowly incorporated into national legislation. Low public recognition of these constant actions in comparison to more spectacular extinction processes is usually the reason (Montiel & Herrero 2010).

A similar situation has been observed during the Russian wildfires in 2010. Smoke from fires burning on less than 400 000 ha affected the Moscow area, triggering a response from the public and politicians while the overall burnt area amounted to five million ha. The great majority of these fires burnt in remote areas in Central or Eastern Russia without causing international or even national attention. They were started mainly by negligent, accidental or even leisure use of fires by people. Understaffed fire brigades with insufficient or inadequate equipment further added to the situation. Behind these deficiencies stands the enactment of the Russian Forest Code on 1 January 2005

which transferred responsibilities for forest fire protection from the state to the regions. These were neither financially nor structurally prepared for these tasks and could also not ensure the enforcement of fire protection responsibilities on private concessions (Goldammer 2010).

Hypothesis IV:

“Common international framework approaches can strengthen the efforts directed at managing forest fires in CEE, especially within the scope of EU policies.”

The openness of decision-making processes to multiple stakeholders is stressed for all four EU member states in the study (Tab. 13; question 5.4). This can be interpreted as the result of a more Europeanised generation of forest laws mentioned earlier (Fredriksson 2003). Nevertheless, the general influence of international guidelines is also existent in Belarus (Tab. 13; question 5.5), while their absence in Slovakia can be attributed to the slow process in developing fire legislation.

It can be said that most member states favour a single EU measure dealing with forest fire prevention. But the existence of national forest policies and the EU's insufficient mandate to act in a compulsory nature on forestry-related issues has so far been standing in its way according to the results of a working group on forest fire prevention (EC 2005). Wildfire strategies are created and implemented by the member states themselves resulting in a wide range of different and heterogeneous approaches. The EU Forest Focus programme from 2003 to 2006, which has at least been partly aimed at forest fires, was never proven to be efficient enough (Farmer & Álvarez-Baquerizo 2006) and even the currently ongoing LIFE+ measure has been deemed insufficient to tackle fire issues in European forests during its drafting phase (EC 2005). Nowadays, also

growing wariness and scepticism towards EU integration processes threaten the goal of reaching more harmonized and coherent strategies (Aguilar et al. 2009).

To reverse this development, an EU Fire Framework Directive has been proposed to harmonise legal frameworks and achieve Integrated Fire Management¹² (IFM) (Lázaro & Montiel 2010). It is meant to handle the issue of wildfires more efficiently and, in particular, further promote the use of fire for fuel management as opposed to the current restrictive regulations in most countries (Lázaro & Montiel 2010). Aguilar et al. (2009) stress that wildfire management is not exclusively affected by policies in the forest sector, but rather stretches over other areas as environment, natural resources, economy and even the energy sector. The policies in these external sectors can have unintended consequences, thus any approaches to an EU policy framework have to be cross-sectoral and involve different stakeholders (Montiel & San-Miguel 2009). Spatial planning can have negative effects on active fuel management through zoning and regulations in protected areas. Agriculture as the main policy field in the EU in terms of budget defines measures and financial support affecting forest management through the Rural Development Policy. Energy policy, although mainly left to the member states, sets the support for renewable energy. And finally environmental policy, which has been assessed with chronic implementation deficits (Aguilar et al. 2009, Montiel & Herrero 2010). All these policies have to be taken into consideration to fight structural causes of wildfires.

12 Integrated Fire Management involves integrating prevention, suppression and the use of fire with the key ecological attributes of fire, i.e. the ecologically appropriate fire regime, and the socio-economic and cultural necessities of using fire along with the negative impacts that fire can have on society (Myers 2006).

Still, the wide ranging effects of wildfires make it difficult to agree on a competent authority that complies with the Union's principle of subsidiarity (González 2010). As fire occurrence and incidence differ between regions, legal and policy frameworks have to be efficiently adapted to the specific ecological and socio-economic characteristics (Montiel & Herrero 2010, Lázaro & Montiel 2010). One example is the use of prescribed burning in most European countries outside the Mediterranean region. In many cases legal frameworks do not exist due to a general ban on the use of fire in forests or other natural areas (Lázaro & Montiel 2010). Nevertheless, it is a very important tool for extinction strategies in Mediterranean countries. Large fires can occur during severe fire weather, thus exceeding the normal capacities for wildfire suppression (Montiel et al. 2010).

Hypothesis V:

"Public education and access to relevant data are important tools in fire prevention as human-caused fires prevail in CEE."

As shown before, human causes of forest fires prevail in the study region and carelessness is the most common reason (Tab. 3). But arson is reported in the case of Poland as well. The experts also see a strong impact of forest fires on rural communities and private forest owners (Tab. 4). Conveying information on wildfires specifically for private forest owners has also been assessed as being less efficient than for the general public or qualified personnel (Tab. 16). As is the case for legal measures, information for the public and also private owners seems not to be effective.

The role of an integrated approach towards training, awareness-raising and structural prevention is emphasised by Rego et al. (2010). It is seen as fundamental that the communication process with the general public is accompanied by a proper use of wildland fire terminology and definitions (Hardy 2005).

Sustained public awareness is a prerequisite for mitigating the problem of careless use of fire (Rego et al. 2010). Extending the general appreciation of forests by clear policy objectives and participation to support sustainable development is highlighted as an important factor in Slovakia (Sulek 2002). Rydzak & Trebecki (2009) show that an informational and educational campaign by the state forest service has significantly decreased forest fires caused by burning adjacent grass- and wastelands within three years. In the Czech Republic, the contribution of advanced training and adjusted education of forest personnel to the decline of forest fire incidents is stressed by Sisak et al. (2004).

Within this context, science and technology transfer are of main importance for advancing wildfire management in Europe (Goldammer et al. 2009b). Knowledge of the ecological role of fire in Eastern Europe is poor as are capacities of human resources and technological approaches (Goldammer et al. 2009b, Lázaro & Montiel 2010). At the same time supplementary aspects of any research effort such as harmonized and internationally accepted procedures for data collection are still an issue. 'Forest fires', 'wildfires' and 'wildland fires' are not always distinguished by countries during the process of data collection and/or provision. Sometimes there is even no distinction made between forests and woodlands (FAO 2007). Other difficulties are availability and quality of the data which in most cases are rather poor, especially in evaluating the monetary impact of wildfires (Biro & Mavsar 2009). Therefore, the development of the EFFIS database can be seen as one successful outcome of the Forest Focus programme (Farmer & Álvarez-Baquerizo 2006). The comparison of data from Schelhaas et al. (2003) with the more recent publications based on EFFIS can be seen as one example. Although also the accuracy of the data available within this project has to be questioned due to possible flaws in recording and conveyance.

Concerning the countries outside of the EU the issue of available and reliable data is of even greater importance. The forest fire expert for Ukraine states that reliable fire statistics exist only for the forests managed by the state forestry committee (68%). For about three million ha those statistics are not available, as is any kind of fire management. Furthermore, small fires of 0.1 to 0.2 ha are usually not included in the statistics. For pre-warning purposes reliable information is extremely necessary, especially in the contaminated zones in Belarus and Ukraine. The radioactive deposits accumulated there in living and dead biomass can be stirred up into the atmosphere by forest fires and transported over great distances as far as Canada (Szczygiel & Ubysz 2006, Wotawa et al. 2006).

The general public might be easily impressed and satisfied by high-tech solutions for fire detection and fighting but more attention has to be given to the underlying causes of wildfires and society's increasing vulnerability (Goldammer et al. 2009b). Funds allocated in basic fire suppression techniques are still considerably higher than those spent on prevention (Herrero et al. 2009). The main focus should be on continuous prevention actions rather than emergency suppression measures (Montiel & San-Miguel 2009). It is vital to uphold the long-term effects of lessons learned after fire events and not only rely on short-dated public pressure when daily life is influenced, as was the case during the Russian wildfires in 2010 (Goldammer 2010).

6 Conclusions for Central-Eastern Europe

With regards to increased fire incidents and their impacts, the biggest challenge Belarus faces are the contaminated zones which are equally important in Ukraine. There, climate change as a driving factor might lead to a spread of fire risk to previously unaffected areas, such as the Carpathian Mountains. This range will also be a focal point in Romania and Slovakia, where the impacts of storm damages, followed by bark beetle attacks or erosion present further challenges to forest and fuel management. In Poland the conversion of pure coniferous stands is seen as an important responding task and will continue to be so. Except for problems that might arise in the foothills of the Carpathians or other mountainous areas in the Czech Republic its forest management seems to respond well to the effects of wildfires. Still, little information can be found on the imminent effects of forest fires on protected areas in CEE. The focus is usually on managed forests while nature conservation issues seem to be neglected within this setting. With the rising importance of

prescribed burning in fuel management, natural fire and disturbance regimes will gain more attention. The integration of those experiences for IFM in forests will with certainty have substantial impacts. Within this approach the number of (deliberate) forest fires could further increase while the actual burnt area declines due to fewer large-scale fires.

Concerning changing ownership structures and fragmentation, the two countries most affected by restitution and privatization processes are Poland and Romania. Fire regimes in Poland are at present strongly affected by neglected forest and fuel management of private owners. However, the change of forest ownership has yet to become an important factor in the near future. In contrast, the Czech Republic has not experienced significant changes in forest ownership just as Slovakia, although state support for private owners is scarce. In Ukraine, privatization has taken place mainly in the forest industry sector and private companies are

contracted only for timber harvest. Restitution in CEE is not about to cease soon and also privatization has been a part of reform processes in many cases. The effects of privatization which primarily result in diminished influence of state institutions can be countered with an adaptation of legal and administrative frameworks. Unlike obligatory restitution processes which return forest properties to their rightful owners. Resulting fragmentation in forest ownership can be countered with consolidations or improved support for forest owners and associations. Yet, these are usually voluntary measures meaning that more efforts have to be directed at increasing willingness and support of private owners.

In terms of policy and law enforcement, only in Belarus and the Czech Republic appear the existing measures to be effective enough to cope with human influence on forest fire regimes. This seems not to be the case for all the other countries where the number of fires increased during the last years, particularly in Ukraine. Still, on the national level varying aspects play important roles. In Slovakia the significance of the forestry sector and the threat of wildfires seem to be underestimated by policy-makers. Further developments within the fire protection project in the Carpathians can help to change this perception. Another challenge for fire management is weak governance. As the Russian example shows, unclear lines of responsibility and underfunded government agencies result from misguided reforms. This can especially be the case when the main reason is to cut costs and reduce personnel of public administrations by any means necessary. Those measures result in administrative structures that cannot properly address issues like arson in Poland or uncontrolled agricultural fires in Romania. Still, problems can be approached. The cooperation of local authorities with ecclesial and educational institutions in one Polish district has led to substantial improvements. These efforts could be adapted on a wider base and serve as an

example for other countries or regions. But the Romanian situation also shows that the focus should not only be on arson or careless behaviour but on instructions for the appropriate use of fire as well, which is an essential component of IFM.

Regarding diversified forest fire regulations, the four EU member states of the study region could make a significant step towards efficient regional and international collaboration provided that the development of an EU Fire Framework Directive exhibits further progress. Changing priorities in other fields will also have an influence on wildfire management in the EU. The Rural Development Policy can have positive impact on fuel management with forest biomass as an increasingly important renewable source of energy. Within this context it is also interesting to note that none of the addressed experts mentioned possible impacts of the Renewable Energy Directive (2009/28/EC). Main emphasis is laid on mobilisation of small dimension wood and harvesting residues as well as increased cooperation among small-scale forest owners for biomass supply. These measures have also been promoted by the EU Forest Action Plan. In general, coordination, capacity building and policy advice by EU institutions also include countries like Belarus and Ukraine, even more so through the FAO and other UN organisations. Coordinating measures help to harmonize fire fighting protocols which are important for transboundary support in fire prevention and suppression. But the question remains whether existing policies and strategies are adaptive enough to cope with the effects of (global) changes in climate, socio-economics and land-use.

Concerning education issues, participation in decision-making as applied by the EU member states, is an important feature to involve the public and generally raise awareness. The missing support for these processes in Belarus and Ukraine is a restraining factor in the

prevention of wildfires. Especially the involvement of NGOs or grass-roots movements contributes greatly in achieving this goal. Moreover, availability of reliable data as well as the access to it will remain an important issue for wildfire research and scientific collaboration. Be it for countries already involved in the EFFIS project or others. Furthermore, the existence of

many different languages within the study region can act as a barrier to cooperation in general. This became clear already during the literature review and is therefore important to consider for any approach to the issue of forest fires in Central-Eastern Europe.

7 References

Aguilar, S., Galiana, L. & Lázaro, A. 2009. Analysis of Wildfire Risk Management from a Territorial Policies Perspective: Strengths and Weaknesses in the European Framework. In: González-Cabán, A. (ed.) 2009. Proceedings of the third international symposium on fire economics, planning, and policy: common problems and approaches. Gen. Tech. Rep. PSW-GTR-227 (English). Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 261-272.

Barbosa, P., Camia, A., Kucera, J., Libertà, G., Palumbo, I., San-Miguel-Ayán, J. & Schmuck, G. 2009. Assessment of Forest Fire Impacts and Emissions in the European Union Based on the European Forest Fire Information System. In: Bytnerowicz, A., Arbaugh, M., Riebau, A. & Andersen, C. (eds.) 2009. Wildland Fires and Air Pollution. Developments in Environmental Science, Volume 8. Elsevier: 197-208.

Benson, R.P., Roads, J.O. & Weise, D.R. 2009. Climatic and Weather Factors Affecting Fire Occurrence and Behavior. In: Bytnerowicz, A., Arbaugh, M., Riebau, A. & Andersen, C. (eds.) 2009. Wildland Fires and Air Pollution. Developments in Environmental Science, Volume 8. Elsevier: 37-59.

Birot, Y. (ed.) 2009. Living with Wildfires. What Science Can Tell Us. European Forest Institute Discussion Paper 15. 86 p.

Birot, Y. & Mavsar, R. 2009. Wildfires Impact in 3D: Environment, Economy, Society. In: Birot, Y. (ed.) 2009. Living with Wildfires. What Science Can Tell Us. European Forest Institute Discussion Paper 15: 33-37.

Bowman, D.M.J.S., Balch, J.K., Artaxo, P., Bond, W.J., Carlson, J.M.C., Cochrane, M.A., D'Antonio, C.M., DeFries, R.S., Doyle, J.C., Harrison, S.P., Johnston, F.H., Keeley, J.E., Krawchuk, M.A., Kull, C.A., Marston, J.B., Moritz, M.A., Prentice, I.C., Roos, C.I., Scott, A.C., Swetnam, T.W., van der Werf, G.R. & Pyne, S.J. 2009. Fire in the Earth System. *Science* 324: 481-484.

Brown, J.K. & Arno, S.F. 1991. The paradox of wildland fire. *Western Wildlands* (Spring): 40-46.

Catry, F.X., Rego, F.C., Bação, F.L. and Moreira, F. 2009. Modeling and mapping the occurrence of wildfire ignitions in Portugal. *International Journal of Wildland Fire* 18: 921-931.

Cirelli, M.T. 1999. Trends in Forestry Legislation: Central and Eastern Europe. *FAO Legal Papers Online* #2. 27 p.

EC 2005. Working Group "Forest Fire Prevention" Proposals To Be Presented To The EC. [Online document]. Informal working group of forest fire prevention experts (WGFFP). Available at: <http://ec.europa.eu/environment/forests/wgffp.htm> [Referred 2 August 2011].

EC 2009a. A Community approach on the prevention of natural and man-made disasters. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Commission of the European Communities. 9 p.

- EC 2009b. Adapting to climate change: Towards a European framework for action. White Paper. Commission of the European Communities. 16 p.
- EC 2010. On Forest Protection and Information in the EU: Preparing forests for climate change. Green Paper. European Commission. 22 p.
- EC 2011. Our life insurance, our natural capital: an EU biodiversity strategy to 2020. Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions. European Commission. 17 p.
- EFFIS 2011. EFFIS - Current Situation. Available at: <http://effis.jrc.ec.europa.eu/current-situation> [Referred 15 May 2011].
- EEA 2007. Europe's environment. The fourth assessment. Office for Official Publications of the European Communities. EEA, Copenhagen. 453 p.
- EU Council 2010. Council conclusions on prevention of forest fires within the European Union. Council of the European Union. 6 p.
- FAO 2005. Forest Fire Management Glossary. [Online document]. Available at: <http://www.fao.org/forestry/firemanagement/13530/en/> [Last referred 06 March 2012].
- FAO 2006a. Global Forest Resources Assessment 2005 – Report on fires in the Central Asian Region and adjacent countries. Fire Management Working Paper 16. 50 p.
- FAO 2006b. Fire management: voluntary guidelines. Principles and strategic actions. Fire Management Working Paper 17. 74 p.
- FAO 2007. Fire management – global assessment 2006. A thematic study prepared in the framework of the Global Forest Resources Assessment 2005. FAO Forestry Paper 151. 135 p.
- FAO 2010. Global Forest Resources Assessment 2010. Main report. FAO Forestry Paper 163. 378 p.
- Farmer, M. & Álvarez-Baquerizo, C. 2006. Climate change and natural disasters: Assessment of EU measures to tackle forest fires, in particular the contribution made by Forest Focus. Policy Brief for the EP Environment Committee IP/A/ENVI/FWC/2005-35. Institute for European Environmental Policy. Brief number 02c/2006: 18 p.
- Flannigan, M.D., Bergeron, Y., Engelmark, O. & Wotton, B.M. 1998. Future wildfire in circumboreal forests in relation to global warming. *Journal of Vegetation Science* 9: 469-476.
- Flannigan, M.D., Krawchuk, M.A., de Groot, W.J., Wotton, B.M. & Gowman, L.M. 2009. Implications of changing climate for global wildland fire. *International Journal of Wildland Fire* 18: 483-507.
- FOREST EUROPE 2010. Assessment of Forest Fire Risks and Innovative Strategies for Fire Prevention. Workshop Report. FOREST EUROPE Liaison Unit Oslo. 48 p.
- Forest Management Institute (Ústav pro hospodářskou úpravu lesu Brandýs nad Labem) 2007. Národní inventarizace lesu v České republice 2001 – 2004 (National Forest Inventory in the Czech Republic 2001 – 2004). Úvod, metody, výsledky (Introduction, methods, results). 224 p.
- Forster, C., Wandinger, U., Wotawa, G., James, P., Mattis, I., Althausen, D., Simmonds, P., O'Doherty, S., Jennings, G., Kleefeld, C., Schneider, J., Trickl, T., Kreipl, S., Jaeger, H. & Stohl, A. 2001. Transport of boreal forest fire emissions from Canada to Europe. *Journal of Geophysical Research* 106 (D19): 22887-22906.
- Fredriksson, G. 2003. General Comments on Forest Legislation in European Countries with Economies in Transition. In: Le Master, D., Herbst, P. & Schmithuesen, F. (eds.) 2003. Experiences with New Forest and Environmental Laws in European Countries with Economies in Transition. Proceedings of the 4th International Symposium; Jaunmokas, Latvia; August 2002. Organized by the IUFRO Research Group 6.13.00. Forstwissenschaftliche Beiträge der Professur Forstpolitik und Forstökonomie. Nr. 29; ETH, Zurich: 11-15.

- Goldammer, J.G. & Crutzen, P.J. 1993. Fire in the environment: Scientific rationale and summary of results of the Dahlem Workshop. In: Goldammer, J.G. & Crutzen, P.J. (eds.) 1993. Fire in the environment: The ecological, atmospheric and climatic importance of vegetation fire: 1-14.
- Goldammer, J.G. 1996. The Boreal Forest, Fire, and the Global Climate System: Achievements and Needs in Joint East-West Boreal Fire Research and Policy Development. *Combustion, Explosion, and Shock Waves* 32 (5): 544-557.
- Goldammer, J.G. & Bruce, M. 2005. The Use of Prescribed Fire in the Land Management of Western and Baltic Europe: An Overview. *International Forest Fire News* No. 30: 2-13.
- Goldammer, J.G., Sukhinin, A. & Davidenko, E.P. 2008. Advance publication of wildland fire statistics for Russia 1992-2007. *International Forest Fire News* No. 37 (in prep.).
- Goldammer, J.G., Statheropoulos, M. & Andreae, M.O. 2009a. Impacts of Vegetation Fire Emissions on the Environment, Human Health, and Security: A Global Perspective. In: Bytnerowicz, A., Arbaugh, M., Riebau, A. & Andersen, C. (eds.) 2009. *Wildland Fires and Air Pollution. Developments in Environmental Science, Volume 8*. Elsevier: 3-36.
- Goldammer, J.G., Rigolot, É. & Birot, Y. 2009b. Conclusions. In: Birot, Y. (ed.) 2009. *Living with Wildfires. What Science Can Tell Us*. European Forest Institute Discussion Paper 15: 79-82.
- Goldammer, J.G. 2010. Preliminary Assessment of the Fire Situation in Western Russia. Analysis of 15 August 2010, presented at the State Duma, Moscow, 23 September 2010. [Online document]. *International Forest Fire News* No. 39 (in prep.). Available at: http://www.fire.uni-freiburg.de/intro/about4_2010-Dateien/GFMC-RUS-State-DUMA-18-September-2010-Fire-Report.pdf [Referred 8 August 2011].
- Goldammer, J.G. 2011. Wildland Fires and Human Security: Challenges for Fire Management in the 21st Century. Paper presented at the 5th International Wildland Fire Conference, Sun City, South Africa; 9-13 May 2011. 11p.
- González, J.A. 2010. An Integrative Approach at European Level for Wildfires: Towards a Framework Directive. *European Energy and Environmental Law Review* 19 (2): 87-101.
- Hardy, C.C. 2005. Wildland fire hazard and risk: Problems, definitions, and context. *Forest Ecology and Management* 211: 73-82.
- Herrero, G., Lázaro, A. & Montiel, C. 2009. A Comparative Assessment of the European Forest Policies and Their Influence in Wildfire Management. In: González-Cabán, A. (ed.) 2009. *Proceedings of the third international symposium on fire economics, planning, and policy: common problems and approaches*. Gen. Tech. Rep. PSW-GTR-227 (English). Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 273-284.
- Hirsch, F., Korotkov, A. & Wilnhammer, M. 2007. Private forest ownership in Europe. *Unasylva* 228 (58): 23-25.
- JRC 2009. About EFFIS. [Online Document]. Available at: <http://effis.jrc.ec.europa.eu/about> [Referred 26 October 2011].
- JRC 2010. At a glance - JRC History - 2000 -> Today. [Online Document]. Available at: <http://ec.europa.eu/dgs/jrc/index.cfm?id=3840&language=en> [Referred 26 August 2011].
- Kempeneers, P., Sedano, F., Seebach, L., Strobl, P. & San-Miguel-Ayanz, J. 2011: Data fusion of different spatial resolution remote sensing images applied to forest type mapping, *IEEE Transactions on Geoscience and Remote Sensing* 49 (12): 4977-4986.
- Koulelis, P. & Mitsopoulos, I. 2009. A Study of the Socioeconomic Factors Influencing Wildfire Occurrence in Mediterranean Basin Countries. In: González-Cabán, A. (ed.) 2009. *Proceedings of the third international symposium on fire economics, planning, and policy: common problems and approaches*. Gen. Tech. Rep. PSW-GTR-227 (English).

Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 314-320.

Kuzyk, A.D. & Popovych, V.V. 2010. ЕФЕКТИВНІСТЬ ВИКОРИСТАННЯ ЛІСОВИХ ПОЖЕЖНИХ АВТОМОБІЛІВ (Efficiency of Using Forest Fire Vehicles). ПОЖЕЖНА БЕЗПЕКА (Forest Fires Safety) 16: 18-24. (In Ukrainian)

Lázaro, A., Solana, J., Montiel, C., Goldammer, J.G., Kraus, D. & Rigolot, E. 2008. Collection, classification and mapping of the current prescribed fire and suppression fire practices in Europe. Deliverable D7.1-3-1 of the Integrated Project "Fire Paradox", Project no. FP6-018505. European Commission. 47 p.

Lázaro, A. & Montiel, C. 2010. Overview of Prescribed Burning Policies and Practices in Europe and Other Countries. In: Silva, J.S., Rego, F., Fernandes, P., & Rigolot, E. (eds.) 2010. Towards Integrated Fire Management – Outcomes of the European Project Fire Paradox. European Forest Institute Research Report 23: 137-150.

Lindner, M., Maroschek, M., Netherer, S., Kremer, A., Barbati, A., Garcia-Gonzalo, J., Seidl, R., Delzon, S., Corona, P., Kolstroem, M., Lexer, M.J. & Marchetti, M. 2010. Climate change impacts, adaptive capacity, and vulnerability of European forest ecosystems. *Forest Ecology and Management* 259: 698-709.

Lorz, C., Fürst, C., Galic, Z., Matijasic, D., Podrazky, V., Potocic, N., Simoncic, P., Strauch, M., Vacik, H. & Makeschin, F. 2010. GIS-based Probability Assessment of Natural Hazards in Forested Landscapes of Central and South-Eastern Europe. *Environmental Management* 46: 920-930.

Majlingová, A. & Sedliak, M. 2010. Social Vulnerability to the Wildland Fire. In: Bezbednosni inženjering (Safety engineering): požar, životna sredina, radna okolina, integrisani rizici: 2. medjunarodna naučna konferencija i 12. medjunarodna konferencija Zaštite od požara i eksplozije: Novi Sad, 21.-22. oktobar 2010. Novi Sad: Visoka tehnička škola strukovnih studija u Novom Sadu, 2010: 136-145.

Malevsky-Malevich, S.P., Molkentin, E.K., Nadyozhina, E.D. & Shklyarevich, O.B. 2008. An assessment of potential change in wildfire activity in the Russian

boreal forest zone induced by climate warming during the twenty-first century. *Climate Change* 86: 463-474.

Mara, S. 2003a. The forest fires in Romania. In: Colombo, A.G. & Vetere Arellano, A.L. (eds.) 2003. Lessons Learnt from Forest Fire Disasters. NEDIES Project. Report EUR 20662: 24-30.

Mara, S. 2003b. The Romanian Experience in the Management of Forest Fires between 1986 – 2001 (Romania). In: Colombo, A.G. & Vetere Arellano, A.L. (eds.) 2003. Lessons Learnt from Forest Fire Disasters. NEDIES Project. Report EUR 20662: 62-72.

Mara, S., Constantin, S.J. & Irimie, D. 2011. Country Report Romania. In: Schmuck, G., San-Miguel-Ayanz, J., Camia, A., Durrant, T., Santos de Oliveira, S., Boca, R., Whitmore, C., Giovando, C., Libertá, G., Corti, P. & Schulte, E. 2011. Forest Fires in Europe 2010. Joint Research Center – Institute for Environment and Sustainability. Luxembourg: Publications Office of the European Union: 49-51.

Maracchi, G., Sirotenko, O. & Bindi, M. 2005. Impacts of Present and Future Climate Variability on Agriculture and Forestry in the Temperate Regions: Europe. *Climate Change* 70: 117-135.

Mavsar, R. 2009 Economics of Wildfires. In: Birot, Y. (ed.) 2009. Living with Wildfires. What Science Can Tell Us. European Forest Institute Discussion Paper 15: 59-62.

Meyer, J. 2005. Fire effects on forest resource development in the French Mediterranean region – projections with a large-scale forest scenario model. European Forest Institute Technical Report 16. 86 p.

Ministry of Agriculture of the Czech Republic (Ministerstvo Zemedelství) 2010. Zpráva o stavu lesa a lešního hospodárství České Republiky v roce 2009 (Report about the state of forests and forestry in the Czech Republic 2009). 114 p.

Montiel, C. & San-Miguel, J. 2009. Policy Analysis Reveals the Need for New Approaches. In: Birot, Y. (ed.) 2009. Living with Wildfires. What Science Can Tell Us. European Forest Institute Discussion Paper 15: 63-67.

Montiel, C., Costa, P. & Galán, M. 2010. Overview of Suppression Fire Policies and Practices in Europe. In: Silva, J.S., Rego, F., Fernandes, P., & Rigolot, E. (eds.) 2010. Towards Integrated Fire Management – Outcomes of the European Project Fire Paradox. European Forest Institute Research Report 23: 177-187.

Montiel, C. & Herrero, G. 2010. An Overview of Policies and Practices Related to Fire Ignitions at the European Level. In: Silva, J.S., Rego, F., Fernandes, P., & Rigolot, E. (eds.) 2010. Towards Integrated Fire Management – Outcomes of the European Project Fire Paradox. European Forest Institute Research Report 23: 35-46.

Montiel, C. & Kraus, D. (eds.). 2010. Best Practices of Fire Use – Prescribed Burning and Suppression Fire Programmes in Selected Case-Study Regions in Europe. European Forest Institute Research Report 24. 182 p.

Moreno, J.M. & Oechel, W.C. (eds.) 1994. The Role of fire in Mediterranean-type ecosystems. Springer-Verlag, Ecological Studies 107. 201 p.

Moreno, J.M. 2009. Impacts on Potential Wildfire Risk Due to Changes in Climate. In: Birot, Y. (ed.) 2009. Living with Wildfires. What Science Can Tell Us. European Forest Institute Discussion Paper 15: 71-74.

Morgera, E. & Cirelli, M.T. 2009. Forest fires and the law. A guide for national drafters based on the Fire Management Voluntary Guidelines, FAO Legislative Study 99, Rome. 175 p.

Moriondo, M., Good, P., Durao, R., Bindi, M., Giannakopoulos, C. & Corte-Real, J. 2006. Potential impact of climate change on fire risk in the Mediterranean area. *Climate Research* 31: 85-95.

Myers, R.L. 2006. Living with Fire – Sustaining Ecosystems & Livelihoods Through Integrated Fire Management. Global Fire Initiative. The Nature Conservancy. 36 p.

Mysleiko, I.G. & Shamal, V. 2001. Forest Fire Situation in Belarus. *International Forest Fire News* No. 24: 12-14.

Niemi, J.V., Tervahattu, H., Vehkamäki, H., Martikainen, J., Laakso, L., Kulmala, M., Aarnio, P., Koskentalo, T., Sillanpää, M. & Makkonen, U. 2005. Characterization of aerosol particle episodes in Finland caused by wildfires in Eastern Europe. *Atmospheric Chemistry and Physics* 5: 2299-2310.

Niklasson, M., Zin, E., Zielonka, T., Feijen, M., Korczyk, A.F., Churski, M., Samojlik, T., Jędrzejewska, B., Gutowski, J.M. & Brzeziecki, B. 2010. A 350-year tree-ring fire record from Białowieża Primeval Forest, Poland: implications for Central European lowland fire history. *Journal of Ecology* 98: 1319-1329

Päivinen, R., Lehikoinen, M., Schuck, A., Häme, T., Väätäinen, S., Kennedy, P., & Folving, S., 2001. Combining Earth Observation Data and Forest Statistics. EFI Research Report 14. European Forest Institute, Joint Research Centre - European Commission. EUR 19911 EN. 101p.

Pausas, J.G. & Vallejo, V.R. 1999. The role of fire in European Mediterranean Ecosystems. In: Chuvieco, E. (ed.). 1999. Remote sensing of large wildfires in the European Mediterranean basin. Springer-Verlag: 2-16.

Rego, F.C., Silva, J.S., Fernandes, P. & Rigolot, E. 2010. Solving the Fire Paradox – Regulating the Wildfire Problem by the Wise Use of Fire. In: Silva, J.S., Rego, F., Fernandes, P., & Rigolot, E. (eds.) 2010. Towards Integrated Fire Management – Outcomes of the European Project Fire Paradox. European Forest Institute Research Report 23: 219-228.

Rigolot, É., Fernandes, P. & Rego, F. 2009. Managing Wildfire Risk: Prevention, Suppression. In: Birot, Y. (ed.) 2009. Living with Wildfires. What Science Can Tell Us. European Forest Institute Discussion Paper 15: 49-52.

Rivas-Martínez, S., Penas, A., Díaz, T.E. 2004. Bioclimatic Map of Europe, Bioclimates. Cartographic Service, University of León, Spain. Available at:

<http://www.globalbioclimatics.org/form/maps.htm>
[Referred 03 August 2011].

Rydzak, W. & Trebecki, J. 2009. Modes of Wildland Fire Fighting through Educational Campaign in Transition Countries in Europe: Case Study of Poland. *Journal of Forestry* 107 (8): 419-424.

San-Miguel, J. & Camia, A. 2009. Forest Fires at a Glance: Facts, Figures and Trends in the EU. In: Birot, Y. (ed.) 2009. *Living with Wildfires. What Science Can Tell Us*. European Forest Institute Discussion Paper 15: 13-20.

Schelhaas, M.J., Nabuurs, G.J. & Schuck, A. 2003. Natural disturbances in the European forests in the 19th and 20th centuries. *Global Change Biology* 9: 1620-1633.

Schelhaas, M.J., Hengeveld, G., Moriondo, M., Reinds, G.J., Kundzewicz, Z.W., ter Maat, H. & Bindi, M. 2010. Assessing risk and adaptation options to fires and windstorms in European forestry. *Mitigation and Adaptation Strategies for Global Change* 15 (7): 681-701.

Schmithuesen, F. & Hirsch, F. 2010. *Private Forest Ownership in Europe*. Geneva Timber and Forest Study Paper 26. United Nations Economic Commission for Europe & Food and Agriculture Organization of the United Nations. 120 p.

Schmuck, G., San-Miguel-Ayanz, J., Camia, A., Durrant, T., Santos de Oliveira, S., Boca, R., Whitmore, C., Giovando, C., Libertá, G., Corti, P. & Schulte, E. 2011. *Forest Fires in Europe 2010*. Joint Research Center – Institute for Environment and Sustainability. Luxembourg: Publications Office of the European Union. 98 p.

Schroeter, D., Cramer, W., Leemans, R., Prentice, I.C., Araújo, M.B., Arnell, N.W., Bondeau, A., Bugmann, H., Carter, T.R., Gracia, C.A., de la Vega-Leinert, A.C., Erhard, M., Ewert, F., Glendining, M., House, J.I., Kankaanpää, S., Klein, R.J.T., Lavorel, S., Lindner, M., Metzger, M.J., Meyer, J., Mitchell, T.D., Reginster, I., Rounsevell, M., Sabaté, S., Sitch, S., Smith, B., Smith, J., Smith, P., Sykes, M.T., Thonicke, K., Thuiller, W., Tuck, G., Zaehle, S. & Zierl, B. 2005. *Ecosystem Service*

Supply and Vulnerability to Global Change in Europe. *Science* 310: 1333-1337.

Schuck, A., Van Brusselen, J., Päivinen, R., Häme, T., Kennedy, P. & Folving, S. 2002. *Compilation of a calibrated European forest map derived from NOAA-AVHRR data*. European Forest Institute. EFI Internal Report 13. 44p.

Schwela, D.H., Goldammer, J.G., Morawska, L.H. & Simpson, O. (eds.) 1999. *Health Guidelines For Vegetation Fire Events*. Guideline Document. World Health Organization. 219 p.

Seidl, R., Schelhaas, M.J. & Lexer, M.J. 2011. Unraveling the drivers of intensifying forest disturbance regimes in Europe. *Global Change Biology* 17: 2842-2852.

Silva, J.S., Rego, F., Fernandes, P., & Rigolot, E. (eds.) 2010. *Towards Integrated Fire Management – Outcomes of the European Project Fire Paradox*. European Forest Institute Research Report 23. 244 p.

Silva, J.S. & Harrison, S.P. 2010. *Humans, Climate and Land Cover as Controls on European Fire Regimes*. In: Silva, J.S., Rego, F., Fernandes, P., & Rigolot, E. (eds.) 2010. *Towards Integrated Fire Management – Outcomes of the European Project Fire Paradox*. European Forest Institute Research Report 23: 49-59.

Sisak, L., Kašparová, I. & Pulkrab, K. 2004. *Passive and active landscape protection measures against fires in the Czech Republic and in the W-UI area Kostelec*. n.C.I. In: Xanthopoulos, G. (ed.) 2004. *Volume of Proceedings. "Forest Fires in the Wildland-Urban Interface and Rural Areas in Europe: An integral planning and management challenge"*. International Workshop, May 2003; Athens, Greece. Mediterranean Agronomic Institute of Chania (MAICh): 173-184.

Stocks, B.J., Fosberg, M.A., Lynham, T.J., Mearns, L., Wotton, B.M., Yang, Q., Jin, J.Z., Lawrence, K., Hartley, G.R., Mason, J.A. & McKenney, D.W. 1998. *Climate Change and Forest Fire Potential in Russian and Canadian Boreal Forests*. *Climate Change* 38: 1-13.

- Sulek, R. 2002. Financing of Sustainable Forestry – Provisions in the Proposal of the Slovak Republic Forest Act. In: Schmithuesen, F., Iselin, G. & Le Master, D. (eds.) 2002. Experiences with new Forest and Environmental Laws in European Countries with Economics in Transition. Proceedings of the Third International Symposium; Jundola, Bulgaria; June 2001. Jointly Organized by the IUFRO Research Group 6.1300 and the USDA Forest Service. Forstwissenschaftliche Beiträge der Professur Forstpolitik und Forstökonomie. Nr. 26; ETH, Zurich: 138-142.
- Szczygiel, R. & Ubysz, B. 2006. Chernobyl Forests. Two Decades after the Contamination. [Online document]. Available at: www.ppoz.pl/down/pwa/fr506a.pdf [Referred 13 July 2011]
- Szczygiel, R., Ubysz, B. & Zawila-Niedzwiecki, T. 2009. Spatial and Temporal Trends in Distribution of Forest Fires in Central and Eastern Europe. In: Bytnerowicz, A., Arbaugh, M., Riebau, A. & Andersen, C. (eds.) 2009. Wildland Fires and Air Pollution. Developments in Environmental Science, Volume 8. Elsevier: 233-245.
- Szczygiel, R. & Piwnicki, J. 2011. Country Report Poland. In: Schmuck, G., San-Miguel-Ayanz, J., Camia, A., Durrant, T., Santos de Oliveira, S., Boca, R., Whitmore, C., Giovando, C., Libertá, G., Corti, P. & Schulte, E. 2011. Forest Fires in Europe 2010. Joint Research Center – Institute for Environment and Sustainability. Luxembourg: Publications Office of the European Union: 44-48.
- Tucek, J., Skvarenina, J., Mindas, J. & Holec, J. 2004. Catalogue Describing the Fire Vulnerability of Landscape Structures in the Slovak Paradise National Park. In: Xanthopoulos, G. (ed.) 2004. Volume of Proceedings. "Forest Fires in the Wildland-Urban Interface and Rural Areas in Europe: An integral planning and management challenge". International Workshop, May 2003; Athens, Greece. Mediterranean Agronomic Institute of Chania (MAICh): 73-83.
- Tucek, J. & Majlingová, A. 2009. Forest Fire Vulnerability Analysis. In: Strelcová, K., Matyas, C., Kleidon, A., Lapin, M., Matejka, F., Blazenec, M., Škvarenina, J. & Holec, J. (eds.) 2009. Bioclimatology and Natural Hazards: 219-230.
- Ubysz, B. & Szczygiel, R. 2002. Fire Situation in Poland. International Forest Fire News No. 27: 38-64.
- Usenya, V.V. & Katkova, E.N. 2004. Economic Assessment of Wildfire Damage in Belarus. Prirodnye Resursy (Natural Resources) 3. The National Academy of Sciences of Belarus & The Ministry of Natural Resources and Environment Protection of the Republic of Belarus: 59-64. (In Belarussian)
- Vacik, H., Arndt, N., Arpacı, A., Koch, V., Mueller, M. & Gossow, H. 2011. Characterisation of forest fires in Austria. Austrian Journal of Forest Science 128 (1): 1-32
- Vélez, R. 2009. The Causing Factors: A Focus on Economic and Social Driving Forces. In: Birot, Y. (ed.) 2009. Living with Wildfires. What Science Can Tell Us. European Forest Institute Discussion Paper 15: 21-25.
- Vuletic, D., Potocic, N., Krajer, S., Seletkovic, I., Fuerst, C., Makeschin, F., Galic, Z., Lorz, C., Matijasic, D., Zupanic, M., Simoncic, P. & Vacik, H. 2010. How Socio-Economic Conditions Influence Forest Policy Development in Central and South-East Europe. Environmental Management 46: 931-940.
- Wotawa, G., De Geer, L.-E., Becker, A., D'Amours, R., Jean, M., Servranckx, R. & Ungar, K. 2006. Inter- and intra-continental transport of radioactive cesium released by boreal forest fires. Geophysical Research Letters 33 (12).
- Xanthopoulos, G., Caballero, D., Galante, M., Alexandrian, D., Rigolot, E. & Marzano, R. 2006. Forest Fuels Management in Europe. In: Andrews, P.L. & Butler, B.W. (eds.) 2006. Fuels Management – How to Measure Success: Conference Proceedings. 28-30 March 2006; Portland, OR. Proceedings RMPS-P-41. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountains Research Station: 29-46.

Zibtsev, S. 2007. Ukraine Country Forest Fire Report 2007. [Online document]. Available at: <http://www.rfmc.mk/pdf/Ukraine/Country-Fire-Report-Ukraine.pdf> [Referred 13 May 2011].

Zibtsev, S. 2008. Forest fires in Ukraine: management and policy. Symposium on Fire Management in Cultural and Natural Landscapes, Nature Conservation and Forestry in Temperate-Boreal Eurasia. [Online document]. Available at: <http://www.fire.uni-freiburg.de/programmes/natcon/ppt/20-EFNCN-2008-Ukraine-1-Zibtsev.pdf> [Referred 6 July 2011].

Zibtsev, S. 2010. Forest, agricultural and pasture burning in Ukraine. Open Burning and the Arctic: Causes, Impacts, and Mitigation Approaches. [Online document]. Available at: http://www.bellona.org/files/fil_Zibtsev.pdf [Referred 11 August 2011].

Zibtsev, S., Oliver, C.D., Goldammer, J.G., Hohl, A., McCarter, J., Niccolai, A., Petrenko, M. & Borsuk, O. 2011. Wildfires Risk Reduction From Forests Contaminated by Radionuclides: A Case Study of the Chernobyl Nuclear Power Plant Exclusion Zone. Paper presented at the 5th International Wildland Fire Conference, Sun City, South Africa; 9-13 May 2011. 11p.

Appendix

Participants in the Questionnaire

Belarus

Prof. Dr. Vladimir V. Usenia

Deputy Director; Forest Institute of the National Academy of Sciences of Belarus

Czech Republic

Prof. Luděk Šišák

Faculty of Forestry and Wood Sciences; Czech University of Life Sciences Prague

Poland

Dr. Ryszard Szczygieł

&

Mr. Bartłomiej Kołakowski

Head/Associate Professor

Junior Technician

Department of Forest Fire Protection; Polish Forest Research Institute

Romania

Mr. Septimius Mara

Senior Counsellor; Romanian Ministry of Environment and Forests

Slovakia

Dr. Andrea Majlingová

&

Dr. Valéria Longauerová

Assistant Professor /University lecturer

National Forest Centre; Slovakian

Department of Fire Protection;

Forest Research Institute Zvolen

Technical University Zvolen

Ukraine

Dr. Sergiy Zibtsev

Associate Professor/Head of International Programs

Institute of Forestry and Landscape-Park Management; National University of Life and Environmental Sciences of Ukraine