ELITE

Elicit to Learn Crucial Post-Crisis Lessons

DELIVERABLE **D4.2**

Forest Fires Lessons Learned Report

Contract number :	*312497*
Project acronym :	ELITE
Project title :	Elicit to Learn Crucial Post-Crisis Lessons

Deliverable number :	**D4.2**
Nature :	Report
Dissemination level :	PU (Public)
Report date :	23rd of June 2013

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The ELITE project was funded by the European Commission under the 7th Framework Programme (FP7) –SEC

Coordinator: TECNUN

VERSION CONTROL

Version	Date	Contributors	Sections Affected
1	30.06.2013	FFI	Deliverable D4.2 submitted to the EU
2	30.06.2014	FFI	Modified Deliverable D4.2 submitted to the EU

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EXECUTIVE SUMMARY

The purpose of this deliverable is to identify what are the most relevant problems related to the crisis management of *forest fires*, and to systematize and analyze any lessons learned. The report captures both the process of learning from crises and the challenges to sharing lessons learned. This is especially important as many groups and organisations lack the capacity and structures to learn from previous incidents. The deliverable is the first of a total of three deliverables in work package four (WP4) in the ELITE project, dedicated to lessons learned from respectively forest fires, earthquakes and floods.

A strong link between forest fires and climate change was identified and research to date indicates that both the incidence and severity of forest fires will increase dramatically. A real case from Poland is presented to describe some characteristics of large scale forest fires. Through the use of various qualitative methods the report presents different lessons identified and learned related to:

- Knowledge
- Interoperability
- Preventative measures
- Equipment, communication, technological innovations
- Recovery
- Learning before, during and after a crisis

The methods used to gather information for this report include a scenariobased workshop in Weeze, Germany, in April 2013 with experts from the ELITE Community of Practice (CoP), as well as a questionnaire which was sent to the CoP immediately after the workshop. The questionnaire was developed to verify information as well as provide information on topics not covered in the workshop. Different sources have been used for the literature review, for example results from the EU projects Firesmart and FUME, as well as the EU Exchange of Experts programme.

The importance of learning from crises and sharing experiences is stated throughout the deliverable. Creating a good environment to share experiences is necessary to learn from crises, and the report presents the Facilitated Learning Analysis Process (FLA), developed and used by the US Forest Service. Some of the principles the FLA process is built upon are meant to promote sharing of information. Furthermore, the report touches upon how challenges related to forest fires are related to different types of learning, such as experiential, explanation based and 'technical and competence' based learning.

Finally, the deliverable includes some best practices to (i) learning, (ii) personnel (competence), (iii) technical equipment and (iv) interoperability. A table is presented summarizing the main lessons learned categorized according to topics defined by the authors when systematizing the results from the workshop, literature studies and questionnaire.

The report was written by Maren Maal and Tonje Grunnan from the Norwegian Defence Research Establishment (FFI). The scenario case that was used as a starting point for the discussions in the workshop was elaborated and prepared by Tonje Grunnan (FFI) with input from Pawel Kepka (SGSP), inspired by the case 'Operation Rudy' in Poland.

1. INTRODUCTION

"*A changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events, and can result in unprecedented extreme weather and climate events*" (IPCC 2012:7)

The latest Intergovernmental Panel on Climate Change (IPCC) report is titled "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation". The report describes how climate change will have an impact on the frequencies of natural disasters. "Research to date indicates that both the incidence and severity of forest fires will increase dramatically" (Flannigan et al. 2000). The result will be longer fire seasons and larger areas will become burned (Wotton and Flannigan 1993; Flannigan et al 2005). Kurz et al (1995) also notes how one will experience "shorter fire–return intervals" and a "shift to a lower forest age-class distribution".

Kurz et al. (1995) argue that a warmer and drier climate is conducive to forest fires and will lead to a "positive feedback loop". In other words, more forest fires lead to greater terrestrial loss of carbon to the atmosphere, which feeds into greater global warming and again more forest fires (Kurz et al 1995). Researchers pose the question whether large numbers of high-intensity fires will overwhelm the fire management agencies and their suppression capacity (Podur and Wotton 2010:1). Thus, Flannigan et al. (2009:501) notes that "the international fire community recognizes that greater international cooperation is required to overcome lack of integration and reduced fire management capacity in the face of increasing global fire activity".

It is in this context that the overarching objective of the ELITE project is to improve European emergency preparedness, response and recovery from disasters. These include natural disasters such as floods, large scale forest fires and earthquakes. One of the major problems today is the lack of interoperability in the face of natural disasters that cross borders. Another problem is that lessons learned knowledge remains fragmented in and between organizations, sectors and nations. This state is maintained through a divided European landscape of organizations with disaster management expertise and responsibilities.

The ELITE project will create a living document containing lessons learned, not only from individual crises, but also insights that are common and apply across disaster types. The ELITE living document will be a publicly available web solution which comprises a "living" repository of best practices and guidelines as well as social media features. The document is "living" which implies that it will be continuously updated by authorized agents so that the guidelines and best practices within the realm of crisis management are continuously maintained.

The living document will be an evolving collection of lessons learned nurtured by a Community of Practice (CoP) for mutual learning and information sharing. However, before the living document is launched an iterative process of gathering and categorizing data will take place. This will lead to lessons learned reports where different crisis will be analyzed according to the four crisis dimensions; all hazards, all phases, all impacts, and all stakeholders. The output of the analysis process is the three lessons learned reports, one for each disaster type (D4.2, D4.3 and D4.4).

In addition, a holistic report where all tangible lessons learned are integrated using an all phases-all hazard approach (D4.4) and a report on categorization for the living document (D4.1) will be produced.This report (D4.2) constitutes the first of the three lessons learned reports and will focus on lessons learned regarding large scale forest fires.

1.1 Research question and objective of the report

This report poses the **research question** *what are the most relevant problems and are there any lessons learned relating to forest fires?*

The report has three objectives that underpin the research question:

Objective (1) - *Gather and systematize knowledge on forest fires*
Objective (2) - *Identify the most relevant problems related to the disaster type; forest fires*
Objective (3) - *Systematize lessons learned in relation to forest fires*

In order to do this, various qualitative methods such as literature review, workshop and questionnaire have been used to gather current knowledge on forest fires. The literature reviewed is a mixture of the most prominent academic articles in the field (Flannigan (2000, 2005, 2009), Kurz (1995), Wotton (1993) and Poudor (2010)), as well as articles from experts from different levels within the crisis management. Findings from the EU Firesmart project and FUME, as well as the EU Exchange of Experts programme, has been referred to. Other sources includes US forest service and Forest Europe.

In order to capture the newest and most relevant information concerning suppression activities, information from a workshop which included experts from different fire management agencies has been used. The workshop on forest fires took place in Weeze, Germany, April 15th-16th 2013. The objective for the workshop was to disseminate and collect procedures, lessons learned and best practices from the experts in the ELITE CoP (see section 2.1.3 for more information about the CoP).

A questionnaire was also developed to verify information as well as provide information on topics not covered in the workshop. Finally, lessons learned are identified and presented together with best practices.

1.2 Relevance and importance of the report

The relevance of the ELITE project becomes apparent when analysing the main conclusions drawn by the IPCC. Here IPCC describes how climate changes will have an impact on the frequencies of natural disasters as mentioned above. The call describes how Europe during recent years has responded to several natural disasters where the human and financial costs are huge. Other disasters, such as major industrial accidents, will to a large degree mobilise similar emergency preparedness resources. Therefore, ELITE chooses a methodology that, starting with natural disasters, will generate insights applicable to a large range of disasters, whether “natural” or “man-made”.

1.3 Plan for the report

The report is structured as follows:

In **chapter 2** the terms will be defined and conceptualized. Different types of learning will be discussed. Contextual characteristics of crisis will be explored as well as an outline of who are the actors and which are the different phases of a crisis.

Chapter 3 includes methodological reflections concerning this report's research process which consists of literature review, participative observation in the scenariobased workshop and questionnaire with key informants.

Chapter 4 concerns the topic of forest fires and is divided into three parts. Section 4.1 refers to EU Firesmart and looks at the causes of fires. Section 4.2 presents and explain the terms used to characterize forest fires in the wildfire literature. Section 4.3 describes a real case of a severe forest fire that happened in Europe.

In **Chapter 5** different reports and evaluations are reviewed in order to gather information on forest fires (EU Firesmart, FUME, US forest Service, Forest Europe, EU Exchange of Experts etc.). In this chapter we will systematize knowledge from primary and secondary sources and identify relevant lessons learned.

Chapter 6 will explore and systematize the findings and lessons identified from the ELITE workshop on forest fires and from the questionnaire. Secondly, best practices related to learning, competence, technical equipment and interoperability will be presented. Finally, we present some challenges related to forest fires and different types of learning.

Chapter 7 sums up the main findings and present a summary table of lessons learned.

2. BACKGROUND

This chapter will conceptualize and define the different terms used in this report. Contextual characteristics of forest fires will be identified.

2.1 Conceptualization and definitions

2.1.1. Lessons learned

The ELITE project has used National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA) definition of **lessons learned**. Lessons learned are defined as:

"Knowledge or understanding gained through experience. A lesson must be significant in that it has a real or assumed impact on operations; valid in that is actually and technically correct; and applicable in that it identifies a specific design, process, or decision that reduces or eliminates the potential for failures and mishaps, or reinforces a positive result".

In other words, "lessons" are the incidents, experiences and the concrete knowledge from the incidents (Støldal 2013). "Learning", on the other hand, can be more difficult to describe and measure. Støldal argues that when a lesson is "learned" it conveys that one has changed behaviour. Therefore one must distinguish between *lessons learned* and *lessons identified.*

2.1.2. Different types of learning

"Learning" can be difficult to describe and measure. Some of the most prominent authors within the study of internal crisis management, Boin, t'Hart and Sundelius, introduce three different types of learning:

Experiential learning is when one has experienced direct exposure to a crisis and has subsequently developed insight about what caused the crisis and how the crisis management worked. Boin et al. (2005) believe that it is about "translating memories into lessons" (2005:117). This type of learning occurs most often with people who work with handling different types of emergencies and who follow contingency plans or Standard Operating Procedures (SOP). This experience makes it easier to compare different types of emergencies and ways to manage a crisis situation. There are few public managers who have experienced multiple crises, and their personal experience is therefore often limited. However, there are other, more indirect forms of learning (Boin et al. 2005:117).

Explanation based learning is when one has "rational-scientific search for the causes of failure and the effect of response" (Boin et al. 2005:117). An example is in the aftermath of a crisis, a committee of scientists and professionals is created to try to find out what was the cause of the crisis, and taking a thorough review of how crisis management and response worked in practice. This type of learning requires independence from political pressures. The committee needs resources and time to conduct this process in an accurate and thorough manner (Boin et al. 2005:117).

Boin et al. (2005) has a third form of learning, *competence or skill based learning*. This implies that during and after the crisis new expertise and technology is created to handle a similar crisis in the future in a better manner. This means that one detects a knowledge gap in specific areas. An example from Norway is from the swine flu pandemic in 2009 where it was necessary for

health professionals to learn about new technologies and acquire new skills in order to deal with the pandemic.

A Working group on experiential learning in the Norwegian Fire and Rescue Services (2013) has developed a model conveying the different steps to achieve experiential learning. The model highlights the importance of connecting the different steps from experiences gathered during an incident, processing these experiences, sharing and using these experiences when a new incident occurs. When all the steps are achieved and experiences are processed, shared and used one can argue that there has been experiential learning. This model will be explored further in work package 5 of the ELITE project that deals with learning processes.

Figure 1: Experiential learning model (*Working group on experiential learning in the Norwegian Fire and Rescue Services 2013*)

There are different methods of learning that may have an impact on the learning process. Abram (no date) in the NTL Institute for Applied Behavioral Science proposed a learning pyramid (based on Maslow's pyramid of needs). Although disputed, it still conveys that different approaches to learning have different impacts. Therefore, this pyramid has been incorporated into the questionnaire in order to capture what experts and professionals within the field of fire services and crisis management argue is the best method to learning.

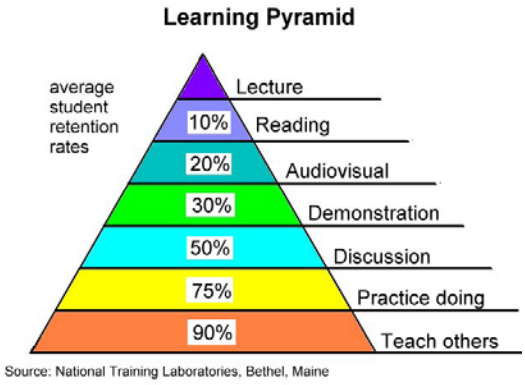


Figure 2: The Learning Pyramid (S. Abram).

2.1.3. Community of Practice (CoP)

The ELITE consortium uses the concept Community of Practice (CoP). CoPs are groups of people who share a common interest and concerns, and who expand their knowledge and expertise in this area by sharing ideas, experiences, insights, tools and best practices (Ruffner, 2010; Snyder, 2003; Wenger 2002). Our understanding is that CoPs will facilitate knowledge exchange and learning. It is an informal network for sharing experiences. These communities enable to share and exchange information, knowledge and experiences, and allow the participants to learn from both the failures that other organizations made and from the best practices that other organizations have (Hernantes 2013).

The ELITE consortium has a strong representation of experienced crisis managers and responders across all phases of crises and of knowledge management experts. The consortium has continuous contact with the CoP which consists of 30 end-users, ranging from first responders to research institutions. This is to insure that the CoP has the best acquisition on classification and analysis of tacit, fragmented knowledge acquired by crisis management responders, and to ensure best practice insights.

The aim is that the ELITE CoP will use the final product of the living document and that it will be used as an arena to share information, lessons learned and best practices. In other words, it will be an evolving collection of lessons learned – a living repository of best practices – nurtured by the CoP for mutual learning and information sharing.

2.1.4. Who are the actors involved in crisis management?

There are many actors involved in managing and responding to natural disasters. The key services are the police, fire and rescue services and ambulances, emergency call centers, hospitals and the municipality crisis management organizations. In addition, Civil Protection units, military units such as the Home Guard, and non-governmental organizations (NGOs) may be called upon. Regional and national authorities get involved depending on the severity of the crises and the need for coordination.

There is also an international aspect when it comes to natural disasters as they may affect several countries. The *EU mechanism* is a good example of cooperation across borders. The EU mechanism was established to support the mobilisation of emergency assistance from participating states in the event of major emergencies. There was a recognition that “EU and countries worldwide are more and more affected by natural and manmade disasters, such as earthquakes, floods, forest fires and terrorist attacks” (EU 2012:2).

In relation to crisis management one can use different levels to be able to explain how the actors relate to each other. The hierarchical levels include a (1) strategic level, (2) operational level, and (3) tactical level. However, the distinctions are not as clear-cut and diverse organizations and actors may use these terms differently. It also varies between countries.

2.1.5. What are the different phases of a crisis?

What is a crisis? A general definition of crisis or a disaster is when: *" […] policymakers experience a serious threat to the basic structures or the fundamental values and norms of a system, which under time pressure and highly uncertain circumstances necessitates making vital decisions"* (Rosenthal, Charles and t'Hart 1989:10, cited in Boin et al. 2005:2).

However, this entails both man-made and natural disasters. Natural disasters can be defined according to the extent of their impacts. In general three main crisis phases can be outlined. These phases are not clear-cut but transcends into each other. *(1) Pre-crisis* (*mitigation, prevention* and *preparation)*. In relation to forest fires this may imply mapping of the vulnerability of forest fires in local and central areas (Kepka 2013). *(2) The Implementation phase (during the crisis):* This phase can be divided into the (i) 'Message phase' which deals with the uncertainty about *what actually happened* and the scope of the crisis, (ii) the 'Action phase' is the actual operation where one *responds* to the crisis. In a forest fire scenario the fire professionals would have established themselves in the target area and the extinguishing of the fire has begun, and (iii) the 'Downscaling phase': The fire professionals have control of the situation and less effort is needed compared to the action phase. *(3) The post crisis phase:* This involves a *recovery* from the crisis situation where one ensures a transition back to business-as-usual. In addition *analysis* may be necessary to investigate the steps parallel to the efforts in the implementations phase.

2.2 Contextual characteristics affecting the development of disasters

The ELITE project organized a Lessons Learned Forest Fires Workshop in April 2013 to find characteristics and criteria for the development of the ELITE living document (van Santen and Illing 2013). Experts from different levels of crisis management were invited to discuss what characteristics related to forest fires they would like to find in the living document. The criteria we arrived at have since been adapted to suit the requirements of the living document (Tecnun 2013). However, these criteria may change as the ELITE project is an iterative process where stakeholders are involved in all steps of the process in order to create a product that are most suited to their needs and interests[1]. Two more expert workshops will take place within the themes earthquakes and floodings, in which discussions of criteria for the living document will also be a topic.

In the forest fire workshop several characteristics were developed, ranging from type of disaster, information characteristics, context characteristics, disaster characteristics, and practice characteristics. This report focuses on the contextual characteristics. After the workshop, Tecnun, with the support from consortium partners Thales and FFI, created a suggestion of characteristics that can be used in the ELITE living document (Hernantes and Goujon 2013). These characteristics will be tested and validated among members of the CoP throughout the project period and are therefore subject to possible changes. The suggestions of contextual characteristics are presented below. They are included as contextual characteristics influences how the natural disaster develops.

[1] See forthcoming deliverables in the ELITE project.

(1) The **geographical impact** of the natural disaster refer to the size of the disaster, whether it is on the local, regional, national or EU/ international level. This has an impact on how many firefighters and resources are needed in the extinguishing activities.

(2) Geological characteristics refer to the terrain where the disaster takes place. For example there are great differences between Mediterranean forests versus. Nordic forests. This may include characteristics like ground types (i.e. pet lands), tree types, vegetation and ground humidity rate. It also becomes important whether the affected area is close to a watercourse.

(3) Weather/ meteorological characteristics can play a crucial role in the development of a disaster. This is related to temperatures, wind conditions and air humidity rate.

(4) Affected critical infrastructures/critical assets may influence the impact of the disaster. This is for example if the disaster affects energy production plants, information and Communication Technology, Transport, Water, Food, Health, Chemical and Nuclear industry and financial assets.

(5) The **emergency duration** can range from hours, days and to months.

(6) Contextual factors related to **human activities** and **day specificity.** For example population density or high value assets to be protected. This can correlate with day specificity (i.e. weekend in August, with high road/rail traffic) or what time it occurs during the day.

(7) Number of **casualties.**

3. METHODOLOGICAL APPROACH

In the following section the methodological approach of this report will be presented. Data triangulation has been done in order to secure the reliability of the findings. Reliability concerns the accuracy and thoroughness in which the data are collected (Hellevik 2002).

3.1 Participative observation through a workshop

Workshops are a fruitful approach to gather information and knowledge among experts. In the ELITE project there will be separate workshops for each of the three topics (forest fires, earthquakes and floods) and a fourth one as integration. Each workshop will take two days and is for invited participants from different countries and different crisis management institutions.

The first workshop, on the topic forest fires, took place in Weeze, Germany, April 15th-16th 2013. The objectives for the workshop were to disseminate and collect procedures, best practices; lessons learned and establish a common understanding of the possibilities for interoperability. Furthermore, the workshop was intended to provide a learning opportunity for all actors involved in civil protection interventions in this type of specific disaster.

However, there are weaknesses with workshops. Actors have different interests, thus it may be difficult to guide the discussions and create a common platform. For example, in the workshop in April 2013, we as researchers wanted to focus on learning processes and sharing, while the practitioners wanted to focus on technical issues and equipment. In international workshops there may be challenges related to languages. A consequence can be that experts with a lot of knowledge and skills may not want to participate and share their insights due to language barriers.

3.2 Scenariobased workshop and group discussions

As a means of gathering knowledge and information about forest fires and what we can learn from these crises, a scenario was developed to provide a basis for discussions in the workshop. The scenario was inspired by “Operation Rudy” which was a response to a major forest fire in Poland (1992). Operation Rudy is described in more detail in section 4.3. By using a scenario case they can relate to, it becomes easier for the participants to share knowledge on lessons learned and elicit best practices from crises.

The scenario described in the plenary session was built up around different factors such as detection and cause, meteorological conditions, description of the development of fire in several steps, requests for assistance and determination.

Main features of the scenario description:

*Country **X** in the EU is experiencing unusually high temperatures and heavy droughts. The heat wave starts in the eastern parts of the country, but is slowly moving towards the central and southern parts. The temperatures rise to record values, 8 °C warmer than normal for July. On 26th of July, around 16:40 a fire is noticed and reported by a hiker in a forest near the mountain area of **Y**. Around 92% of the forest consist of thoroughly dry combustible material, originating from natural decomposition of trees. The layer of rotting wooden material reaches 20 cm, that increases the rate of fire spread. The police believes the cause of the fire is unintentional, caused by sparks from train breaks. The air temperature during the day is between 31-38°C. Last registered rain in that area was 2 months earlier.*

The fire is spreading very quickly. After about 2, 5 hours, 180 ha of forest is on fire. In the evening the speed of fire spread is reaching 3, 9 km/h. Immediate change of wind direction and abnormally quick fire spread is resulting in firefighters being trapped and surrounded with fire. The fire claims the life of two fire fighters and another is injured. At 11:00 on July 27th, 6000ha is burnt out. The heat wave deteriorates the situation. The fire fighters have problems putting out the fire. Fire operations are extremely difficult, especially due to terrain characteristics.
*There is a large lake nearby, but is difficult to access. The water must be transported kilometers from the sources. A number of new outbreaks are registered daily. The fire starts in a rural area sparsely populated, but is spreading fast and approaching the town of **Z** with 5000 inhabitants. Constant change of fire conditions is forcing commanders to change the strategy a number of times. As the fire is spreading fast, firefighters from different parts of country **X** are requested to assist in the fire operations.*

*The situation requires coordination at national level. Country **X** asks for a request for assistance from their neighboring country. After another three days, country **X** sends a request for assistance to the EU CIM.*
Intense fire operation eventually leads to the limitation of fire spread in the morning of 8th of August, and extinguishing the fire at its boarders. In total 9670ha is burnt out. The operation is finished on 15th of August.

After the scenario case presentation, the workshop participants were to identify common problems at a superior level, and then to go into more detailed descriptions and explanations. The CoP participants, were separated into three groups with a mediator and a person taking notes. The topics for the group discussions were:

1) *What are the common problems within and between:*
   a) Organisations
   b) Management levels
   c) Countries

2) *What are the procedures of crisis management?*
   a) At different levels and/or for different activity
   b) Strategic level
   c) Tactical level
   d) Operational level
   e) Across levels

3) *What are the interoperability challenges and how can they be improved?*
   a) Personnel/Responders
   b) Equipment
   c) Cross-border

Furthermore, the mediator of the group discussions posed questions to the CoP in order to extract as much information as possible. The general questions were:

- What are your experiences of using scenarios in preparing and learning from crises?
- Have you shared scenarios with colleagues in other countries?
- What do you do when preparing for such a crisis outlined in the scenario presentation?

More specific questions were:

- Imagine you are an operational fire fighters in country X: What kind of information would you be interested in?

- Imagine you are a policy maker in country X: What kind of information do you need to prepare for this scenario?
- How do you learn from your mistakes? How do you deal with lessons learned from one crisis. Are you using lessons learned from crisis to prepare for new crisis, if so, in what way?

Questions regarding "what do you do when preparing for such a crisis…" is related to identifying common problems. The information will be used to gather knowledge on what are the main problems in preparing for, and analysing and learning from, crises between organisations and countries, at the same level or across levels, and within the same kind of crisis or across crises. One hypothesis is that you will find the same kind of problems in many types of crisis/disasters.

The aim of the questions regarding "what kind of information are you interested in, and, when preparing for such a scenario" was to reveal what kind information is hard to find today and will be interesting for the participants to find in the ELITE living document.

3.3 Literature review

Different material from national evaluation reports, reports from previous EU-projects, reports from forest Europe, to more academic papers has been used in this report. The main EU-projects referred to is EU Firesmart, EU Exchange of Experts progamme and FUME. Information from the US forest service has also been used.

Field reports from the EU Exchange of Experts programme was used to convey how the relevant actors themselves identified problems and travelled to other countries to learn about best practices. The programme is "designed to complement a training programme tailored to the needs of civil protection interventions within the framework of the Community Mechanism for Civil Protection" (EU Exchange of Experts, no date).

3.4 Questionnaire with key informants

A questionnaire can be defined as "*a research instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondents*" (Wikipedia 2013). The questionnaire constructed for this report concerned best practices from different phases of a crisis, and how lesson learned procedures were conducted in their organization (see appendix A).

In this report the key informants consists of professionals dealing with forest fire at the strategic, operational and tactical level. Andersen (2006:279) defines key informants as "*people who are assumed to have an especially good overview and insight into the question the researcher wants to examine*". The questionnaires were sent out to the experts at the forest fire workshop, and were also further distributed within their organizations. This is termed "purposive sampling" where the "researcher samples on the basis of wanting to interview people who are relevant for the research questions" (Bryman 2004:334). This is a non-random sample, which may have led to a skewed sample of respondents. The findings from the questionnaire are presented in chapter 6.

4. FOREST FIRES

This chapter will first address forest fires as a worldwide problem, secondly characteristics describing forest fires from secondary literature will be presented. Finally, a case study of a severe forest fire in Europe will be explored.

4.1 Forest fires - a worldwide problem

The Food and Agriculture Organization of the United Nations (FAO) records that every year between 300 and 400 million ha are burned in the world. The answer to the forest fire problem has been the implementation of costly extinction systems in developed countries, especially in Europe. However, there are no strategies in place that modify the causes of forest fires. This is due to the fact that the causes, though they are well known by experts, are a mystery for the whole society and the media. As mentioned earlier, forest fires are a societal problem that causes significant environmental and economic impacts. To combat the forest fires problem forest managers can apply different management measures.

Firesmart (an EU-project dealing with forest fire prevention) argues that "nowadays wildfires in Europe result mainly from the socio-economic development and the consequent change in life habits" (Firesmart 2010:87). In other words, forest fires are linked to "modern models of life, increased mobility, tourism and recreational activities which increase the number of visitors in the forest" (ibid). It is well documented that fire is used in agriculture, civilculture and livestock breeding, and it can be considered to be a "traditional instrument for the management of Mediterranean ecosystems".

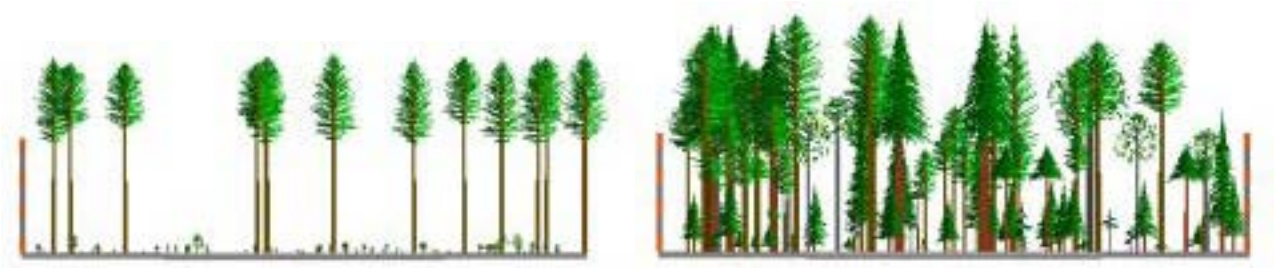
The main driving factors of ignitions can be classified in two categories: (i) *human factors*, dominant in Europe (Firesmart 2010:87). *Human factors* may be intentional such as arson or unintentional sparks from railway, equipment, power line arcs or discarded cigarettes. The second category is (ii) *environmental factors* mainly due to forest fuel (shrub, litter, and dead material), physiography and weather (ibid). Some examples of environmental factors may be lightning, sparks from rockfalls, spontaneous combustion and volcanic eruption. However, in many instances the causes of forest fires are unknown.

Nevertheless, this report will not focus on the factors of ignition causing the forest fires. Rather it will outline some lessons learned before-, during and after a crisis. In natural disasters human action as emergency planning and preparedness can shape the impact of a crisis. In the aftermath of a crisis there is room to assess how the existing arrangement works in practice.

4.2 Characteristics describing large scale forest fires

There are many characteristics that describe forest fires. According to Firesmart (2010:104) the *stand structure of trees* (i.e. the spatial arrangement of trees) "has been demonstrated to be a key factor influencing fire behaviour above other stand characteristics like species composition". The stand structure defines the "amount of biomass that can burn and therefore the energy that can be released during a fire at different stand levels". US Forest Service notes how 'forest fuels'; shrub layer, grass layer, litter at the surface level and live and dead material in the canopy of the trees may accumulate over time. This changes the forest structure and leads to "greater continuity of fuels between the ground surface and the upper tree canopies" (US Forest Service 2003:1, see illustration below). The altered structures functions as "ladders" so that the

wildfire can climb up in the tree tops. How the trees are situated in the spatial arrangement may therefore influence the availability of 'fuel' and how the fire can spread.



Historical *Present*

Figure 3: Changes in forest stand structure (US Forest Service 2003:2)

US Forest Service (2003:2) created a hypothetical simulation of changes in order to show the changes in forest stand structure. Today's forests are more spatially uniform, with higher densities of fire-intolerant species and suppressed trees.

Surface fires only burn the fuel layer just above the ground fuels, while ***ground fires*** are fires burning roots, organic soils, buried logs etc. (named ground fuels). ***Crown fires*** burn in "elevated canopy fuels that consist of the live and foliage and the fine live and dead branchwood" (Firesmart 2010:104). US Forest Service (2003:1) notes how "crown fires are intense and fast-moving […] Crown fires are virtually unstoppable, and often results in large burned areas despite costly and dangerous fire suppression efforts". Firesmart (2010) stresses that most fires in European forests are ground fires and crown fires.

Another dimension that has an impact is the tree dimensions and bark thickness. Firesmart (2010:108) outlines that the resistance of trees to fire increases with age; "Increasing crown size, stem diameter, total height and height to crown base and bark thickness lead to higher tolerance to fire". However, the relative importance of these abovementioned attributes and the age of the trees is dependent on what type of species it is and other environmental factors (site and climatic conditions). For example some species of trees can be more detrimental in a fire than others. Here there is a difference between the Mediterranean features versus the Nordic features of forests. For example in the Polish forest fire named "Operation Rudy" (elaborated upon in section 4.3), Pine trees were believed to have great contribution to the fire spread (Kepka 2013). The needles from the pine trees contain essential oils. When the pine trees caught fire the oil from the needles began to evaporate and the oil vapour from the trees were responsible for creating an explosive atmosphere (micro-level). These micro-explosions served to transport small burning materials 600 m, or exceptionally, even 1000 m away from the fire (Kepka 2013).

Flannigan et al (2009:494) uses terms as ***fire weather.*** Fire weather is defined as "the weather variables that influence fire behavior, starts, and suppression" (ibid). These variables include (i) temperature, (ii) precipitation, (iii) humidity, and (iv) wind. These weather factors are predicted to change for much of the world and thus fire weather can be expected to be affected by climate change (IPCC 2007 cited in Flannigan et al 2009:494). In ELITE this term is captured through meteorological and geological factors (see section 2.2).

Fire occurrence is a measure of "fire activity that quantifies the presence or absence of an event" (Flannigan et al 2009:495). In other words, a fire occurrence is the starting point from

which a fire can grow to be large or alternatively extinguished, either through direct suppression or without human intervention.

Flannigan et al (ibid) argue that "changes in climate will influence the future occurrence of wildfire through myriad pathways that involve weather conditions conducive to combustion, fuels to burn and ignition agents". When and where the occurrence of fire happens is particularly critical to fire management agencies. It is when large numbers of fires occur over a short time period that a management agency can become overwhelmed and not be able to take action when new fires are ignited (ibid). It is during these times that fires have highest probability of escaping and burning significant areas. The direct effect of climate change on fire occurrence will be through fire weather, as it affects the moisture content and sustained ignition of fuel.

Another concept is ***fire season***. Globally, there is no distinct or common fire season. Though individual regions tend to have 'high' or 'active' fire season. Through satellite reconstruction of hot spots (due to wildfire) one can see that there is always fire activity somewhere on the planet. Thus, Flannigan et al (2009:497) argue that the impacts of climate change on fire season cannot be generalized to any simple single expected outcome. However, in a study of wildfire in the USA, Westerling et al. (2006) found that the fire season length had increased by over 2 months over the 1980s. The researchers used data from 1970 to 2003, the researchers attributed the earlier start of the fire season to earlier snowmelt from higher spring and summer temperatures (Flannigan et al 2009:498). Flannigan argue that the future fire regimes will result in greater fire loads in the spring or fall seasons and that the "fire management agencies will need to expand their current fire suppression capacity beyond the historical fire season limits". Such changes do not present technically insurmountable problems, but "highlight the need to anticipate more subtle changes that arise from interaction of increased fire activity with fire management capacity".

Fire intensity is defined as a "measure of energy output and is a function of the fuel burning and fire weather conditions". Given that changes in climate will affect the growth and distribution of vegetation as well as weather conditions, the net result on fire intensity is a challenge to predict (Flannigan et al 2009:498).

As mentioned in the introduction the international fire community recognizes that greater international cooperation is needed. Flannigan et al (2009:501) outline that a strategy to enhance international cooperation in Fire Management includes "(i) development of international standards and systems for fire early warning, monitoring, impact assessment and reporting; (ii) training and technology transfer; (iii) policy, planning, and institutional support; and (iv) research.

4.3 The Polish case – Operation Rudy

"[...] I remember the fear I saw in the eyes of citizens of Kuźnia Raciborska. That the fire will change direction and burn down the city. The people didn't sleep at night, standing at the roofs of own houses, watching the fire [...] The fire was spreading through treetops, it was the worst thing I've seen in my entire life" (Jan Twardawa, Commandant of Volounteer Fire Service in Kuźnia Raciborska)

The Polish case, Operation Rudy, is included because it is a real case that people and emergency workers can relate to. This was one of the largest forest fires in Europe and was properly documented afterwards. All information and pictures on the Polish case is provided from Kepka (2013).

On 26th of August 1992, around 13:50, a fire was noticed close to railway connecting Racibórz and Kędzierzyn. Because of geological and meteorological factors this became one of Europe's biggest forest fire covering about 50 000 ha.

Picture 1: The length perimeter of the Fire in Operation Rudy.

It was believed that the most probable cause of ignition of the fire was a mechanical spark, generated by friction, from a passing train that went through the forest area (i.e. Human unintentional factor). The affected forest area consists of a number of urban areas. It is surrounded by large cities and smaller settlements (critical infrastructure). Several public roads as well as railways are crossing the forest.

A problem was that the forest consisted of ca. 92% of the dry combustible material (forest fuel), originating from natural decomposition of trees. The surface fuel consisted of a 20 cm layer of rotting wooden material. The decomposing trees and forest fuel served as 'ladders' and created continuity between the surface fuel and the tree tops. This increased the spread rapidity. After about 2 hours and 50 minutes, 180 ha of forest were already on fire. A lesson learned is to clean and remove forest fuels in areas that are vulnerable to forest fires.

From the citation above one noted how this was a crown fire as it "*was spreading through the treetops*". As noted before, crown fires are "virtually unstoppable". The meteorological conditions also had a huge impact. The last registered rain in the forest era was 3 months before. It was also a hot day with a temperature ranging from 31 and 38°C with relatively low air humidity: 15-17%. There was also changing winds (6 to 18 m/s) which made the operations harder as one was not sure how the fire was going to develop and which direction it was going. This forced the commanders to change the strategy several times. Fire operations were extremely difficult due to geological factors. For example the water had to be transported many kilometers from the source.

Picture 2: Polish Fire fighters with fire trucks and helicopters in action

A couple of hours after the fire was noticed (around 16:10, 26th of August), the fire spread rapidity was reaching 3,9 km/h. One experienced a fast change of wind direction and abnormally quick fire spread due to forest sectors containing young trees. This resulted in 5 engines (20 firefighters) being trapped and surrounded by fire. Although rescue operations began immediately, two firefighters died in the flames.

Picture 3: Fire trucks that got trapped in the fire

As firefighters from the whole of Poland were dispatched to reinforce fire operations national coordination was needed. The first priority was to stop the fire from spreading. In order to achieve this different actors became involved, ranging from Military, Police, Civil Defense and other institutions. The people who analyzed the fire spread and who developed strategies for managing the crisis were fire commanders, foresters and other specialists. The analysts in the field headquarters prepared daily reports delivered in the evening with the most reasonable strategy for following day. Every officer in charge (OIC), including the Head of State Fire Service, were basing their decisions on these reports. Every officer responsible for a particular sector of fire operations was briefed during the night. Therefore one could begin to implement the new or modified, give orders and detailed tasks for the supporting services (military, police, foresters, civil defense, etc.).

A communication team was established to facilitate the information flow between various actors involved and the fire brigade, as well, as within fire brigade itself. Coordination was difficult because the area that was affected by fire was enormously wide; there were 10 000 rescuers involved and great number of equipment.

Another group dealt with the logistics, the group was responsible for all kind of supplies. This proved to be challenging as it was a hard task to ensure the appropriate supplies for the involved actors. The logistics were responsible for supplying (i) Petroleum, Oils, Lubricants (POL), (ii) extinguishing agents and various kind of equipment, (iii) food, temporary accommodation for people involved and (iv) repair parts and components for damaged equipment.

In summary, the fire claimed the lives of two firefighters and one civilian who got killed in traffic accident at the field of fire operations. 9062 ha of forest was destroyed. The total financial loss was 516 billion złotys (forest stand), 8 billion złotys (destroyed fire equipment), and 67 billion zlotys (the cost of fire operations). On the other hand, because of large scale fire operations around 40 000 ha of the forest and twelve towns and settlements were saved. Critical infrastructure like a number of important industrial areas (including two chemical companies and a petroleum base) were saved.

5. LITERATURE REVIEW

Different reports and evaluations were reviewed in order to gather information on forest fires. In this chapter we will systematize knowledge from primary and secondary sources and identify relevant lessons learned.

After a literature review it became apparent that frequently big fires exceed the capacity of the firefighting services. Put simply, the fires cannot be controlled. Some examples of "mega fires" are the Forest Fires in Greece during the summer of 2007 which led to the death of 78 people (Forest Europe 2010:23). The 27th of June, 2007, sparks from a powerline ignited a fire near the village of Dervenohoria in Greece. The fire was attacked ineffectively and one day later it burned most of Parnis National Park near Athens. Only a month later, 24th of July, a fire started in a garbage dump in Aigialia. The fire was initially controlled, but not guarded properly. It therefore re-started and burned down more than 30,000 ha.

The fire investigations conducted in Greece found the following causes for fire:
(i) An old woman burning grasses in an agricultural field (The Parnon fire),
(ii) another one cooking on an open fire in her yard (Paleohori fire),
(iii) a shepherd practicing traditional (illegal) burning (Taygetus fire),
(iv) a case of trying to eliminate criminal evidence in relation to a marijuana plantation (Sekoulas fire),
(v) property disputes (Mistos of Evia fire),
(vi) sparks from use of a metal cutting device (Mesorahi of Evia fire).

The other Mediterranean countries convey a similar picture. All southern European countries have experienced extreme fire seasons and catastrophic single fires in the last two decades. For example, arson was the cause of the tragic Horta de Sant Joan fire in 2009, Catalonia in Spain. The fire ended up killing five firefighters.

These examples of large fires and the damage they can cause convey the importance of identifying lessons that can turn into lessons learned. This chapter includes different lessons identified from evaluation reports from various countries. The lessons identified were related to (i) interoperability, (ii) preventative measures, (iii) recovery, (iv) equipment, communication, technological innovation and finally (iv) learning. These topics were also highlighted by the CoP during the scenario discussions in the workshop.

5.1.1. Mediterranean features of forest fires

This report has focused on a case from Poland (section 4.3) and general characteristics describing large scale forest fires (section 4.2). There are great differences between the Mediterranean characteristics versus nordic characteristics, such as topography, climate, tree types etc. However, in the following sections differences and similiarities in responding and managing forest fires in northern and southern European countries will be described. In spite of geographical differences, there are good examples of information sharing and learning from each other's experience.

The project FUME has especially focused on the Euro Mediterranean countries (EUMed) and argue that fire activity has been changing in the EUMed countries due to industrialization and that people have migrated from rural areas (FUME 2014:2). In the last decades the mediterranean landscapes have been dynamic. Where hazardous changes in the landscape has occurred fires have often burned. Fires have responded to the changes "independently of whether they were planned (e.g., afforestation) or unplanned (land abandonment)" (FUME

2014:2). These changes are driven by socioeconomic factors which are likely to continue in the future. Some preventative measures in EUMed countries are written in section 5.1.3.

FUME (2014) argue that "fires do not burn equally all areas in a landscape […] Furthermore, positive feedbacks driven by fire have been documented across Southern Europe". In other words, fires favour burning again in a short time (FUME 2014:2). It is important to understand how the positive feedbacks works to "prevent certain areas entering into fire-driven degradation loops" (ibid). A particular area of risk is the rural-urban interface (RUI).There are methods for mapping the RUI and the EUMed countries should "model fire risk in relation to RUI characteristics" to reduce risk and this "knowledge should have an increasing role in operational fire risk systems that focus on prevention activities" (FUME 2014:2).

5.1.2. Interoperability

After an exchange of experts in Italy, Karageorgiadis (2011:1) from Greece noted how one must enhance interoperability with medical teams. This was echoed by the Norwegian Directorate for Civil Protection (DSB) who wrote in 2008 that there are challenges related to interoperability between the different agencies and directorates within Norway when it comes to large forest fires. DSB points out that different terms and concepts are used in the various agencies and that this can prove problematical when one cooperate in large crisis (DSB 2008:41). However, in Norway one has begun to implement an Incident Command System which will lead to common guidelines concerning command and control. This will better the conditions for management of large scale crisis between different agencies (DSB 2008:41).

Several European countries have adopted this system. For example professional firefighters from France went to the Fire Service College in the UK through the EU Exchange of Experts in order to learn more about the Incident Command System (Poyau 2012).

A similar finding was voiced by Papageorgiou (from the Forest department in Cyprus) who conducted research on the national forest fire prevention systems in Europe and sent a questionnaire addressed to all national representatives at the Forest Europe Workshop (Forest Europe 2010:21). He found that there are no common and harmonized definitions with regards to the prevention of forest fires. Forest Europe (2010:16) also noted that in the European Union there are many initiatives concerning forest fires, but they lack coordination. Forest Europe proposed that one should disseminate and share experiences between countries. The ELITE project attempts to facilitate sharing across borders which may improve interoperability challenges.

A lesson identified through an Exchange of Experts programme in Portugal 2012 was the challenge of interoperability between volunteers and professional fire fighters. The Portuguese fire fighters reported that volunteers and professional fire fighters modes of work must complement each other (Fire-Fighters of the District of Aveiro (FBDA) 2012). This was also stated by DSB who argue that there are significant challenges associated with the use of volunteers who do not have the necessary safety equipment or previous training for extinguishing forest fires. A fire-extinguishing operation must never entail danger to the life and health of volunteers. DSB recommended that fire departments should in their contingency planning have contact and enter into agreements with relevant people from the civil society that can assist during forest fires. Often they may have local knowledge of the forests that may be essential for the operation. Forest Europe (2010:16) noted that in order to facilitate involvement one must make sure that funding reaches local actors (local multipliers).

5.1.3. Preventative measures

When big fires cannot be controlled and exceed the capacity of firefighting services one must take the appropriate preventative measures in order to avoid catastrophic events and, in case they occur, to be prepared for them (Forest Europe 2010:10). According to Forest Europe (2010:23) it becomes obvious that all known fire prevention measures are needed when one deals with large fires. "Prevention should not focus only on public education campaigns, better fire investigation, punishment of arsonists, better surveillance etc., but also on maintaining forest vegetation to safe levels, developing safer RUI areas, and of course preparing sophisticated pre-suppression plans that well-trained and equipped firefighting forces can apply effectively" (Forest Europe 2010:23).

A good preventative measure was observed by a UK expert in another visit through the Exchange of Experts programme (UK Fire Service 2011:2). He noted that Portuguese firefighters had prescribed burnings in the non wildfire season. The Group Analysis and Use of Fire (GAUF) teams in Portugal carried out prescribed burning to help the prevention of possible future fires. The professionals worked closely with the land owners, either under burning trees, or burning off a variety of vegetation. This was done to clear the land of excessive forest fuel loading and stimulate growth. He noted that there were a number of examples when this form of preventative burning had been shown to be successful when comparing it to areas that had not had any prescribed burning carried out.

Pinaudeau (in Forest Europe 2010:11) explains how the prevention scheme works in practice. The preventative actions undertaken include:
(i) maintenance of tracks,
(ii) firebreaks,
(iii) water points,
(iv) fuel management and
(v) monitoring for early detection (ibid).

Preventive measures against forest fires in this area seem to be effective and economically efficient. During the Forest Europe workshop several commentators stressed the "importance of active management in the bottom-up approach, the need to put resources into active management of the landscape and to consider how the market could be utilized for promoting forest management". Other attendees pointed out the need for higher social and political recognition of sustainable forest management as a provider of valuable environmental services and of renewable raw materials such as cork and wood. The public recognition of the contributions made by sustainable forest management fall well below those of other sustainable practices such as, for example, organic agriculture. The problem concerning many forest properties with an absentee owner was raised along with related difficulties in identifying responsibilities for the lack of management.

Xanthopoulos (in Forest Europe 2010:22) stated that forest fires are a serious problem in all the countries of Mediterranean Europe. Each summer thousands of fires in each of these countries mobilize significant resources for fire suppression. In exceptional years, when the conditions favor fire eruption, acceleration and spread, fires can get very large, with catastrophic outcomes. He argues that over the last decades this has prompted serious efforts both within countries and at the EU level to address the forest fire problem, but so far the results are not satisfactory (ibid). As a preventative measure forest fire statistics are used. Forest fire statistics are important and necessary tools for analyzing the fire problem and determining how to best manage it. Examination of such statistics in numerous studies in countries with Mediterranean climate, shows that, as a rule, a small number of fires contribute most to the total area burned. These few fires are the ones that grow very large under extreme weather conditions, exhibiting

fire behavior that makes firefighters clearly unable to intervene for as long as the adverse weather persists. However, in order to have comparable and comprehensive forest fire data, a harmonized methodology must be developed and disseminated for use by the European Countries (Forest Europe 2010:22).

Mavsar (In Forest Europe 2010:11) argued that the limited data required to create forest fire statistics is not readily available because impact assessments of forest fires are often incomplete, efficacy of prevention measures is almost never conducted, and total costs of prevention policies are unknown due to fragmentation of measures and budgets across different levels and actors. Improving the information sources could support future choices in forest fire prevention as an integral part of fire management.

Experiences from large forest fires in Norway conveys that the local management and organizational apparatus related to forest fires often requires more resources, which is often not available. When visiting Skien Fire Brigade the Fire chief explained how they cooperated with the neighboring municipalities (Skien Fire Brigade 30.05.2013). The Fire chief explained that when they received an emergency call they would (i) use their local knowledge and create a worst case scenario, (ii) would contact relevant agencies and fire brigades from neighboring municipalities. When the other fire brigades were alerted they would immediately send a fire truck. However, if it was not as bad as one expected one could call off the additional help. The Fire chief noted that it is better to call one too many times, than not make the call and suffer the consequences (better safe than sorry). However, the responsibility is still with the affected municipality.

Thus, regardless of organizational structure municipalities with significant risk of wildfire must be prepared by (i) being able to facilitate a large number of troops, more resources and management of a forest fire over time. (ii) The municipality must have binding agreements with other fire departments, forest owners, and other people with other resources. (iii) The municipality must have adequate supply of equipment, maps etc. and (iv) a practiced fire management crew (DSB 2008:49).

According to Forest Europe (2010:10) experience shows that when weather conditions are extreme and fuel has built up, different sources of ignition (natural lightning, human negligence and arson) can cause forest fires that may be catastrophic if firefighting services are unable to quickly bring them under control. Thus, because the risk related to forest fire is related fire weather the meteorological institutes can play a role in creating a forest fire danger index which can be used as an instrument reporting on elevated risk of forest fires (DSB 2008:56). The UK fire service wanted to use a similar tool predictive tool, Wildfire Prediction System (WPS), which was developed in Portugal (UK Fire Service 2011).

5.1.4. Recovery

DSB (2008:68) recognizes that a forest fire can be brutal and can have a large impact on the affected municipality. It can have an economic impact for the future municipal revenues, a psychological impact as citizens may experience collective grief and be strongly affected by the incident.

The municipality is responsible for normalization and reconstruction after a large scale forest fire. But it may in some cases be a need for government assistance in terms of cost sharing. It is important that it can be set in motion a process to consider the future use of and reconstruction of a burned area.

Little research has been conducted on the recovery from forest fires. According to Pacific Northwest Research Atation (2007:3) “trees that are severely damaged by fire but not killed immediately usually die within 2 years”. How the forests regenerate depends on a combination of past and future events “How severe was the fire? What was growing before the fire? How long ago was the last fire? What management actions will occur?” (ibid). Each large wildfire is an opportunity to conduct studied and expand our knowledge about postfire management as our current knowledge is limited.

5.1.5. Equipment, communication and technological innovations

The Portuguese Fire Service has specialized wildfire teams and has made a new type of tool which was designed from the teams themselves. It is a multi-function tool that is made of hardened steel with a hard wood shaft. The tool is very versatile and can be used to pick, drag, cut and dig vegetation as well as cut wire fencing (UK Forest Service 2001:5).

After the Froland fire in Norway in 2008 one had to replace the old fire extinguish equipment. Several firefighters experienced that older air cooled fire pumps stopped while they were in the response phase. This decreased the security for the firefighter who had reduced protection when extinguishing capacity did not function. It also weakened the overall emergency response.

There are different chemical means of extinguishing fires on the market. These chemicals are seldom tested, both for environmental and economic reasons, and will therefore be difficult to adopt appropriately. They must be carefully considered and tested before taken into use. Experience after fires shows that many suppliers are active in order to sell their own products in such situations. The evaluation of such products must be left to specialist agencies. It is further important that specialist agencies keep updated on the technical development in this area.

In Norway, the police, health services and fire and rescue services have had separate radios built on old analog technology. A digital radio network for emergency and public safety agencies called Nødnett, is being established. A common network makes it possible to communicate directly between emergency services which facilities interoperability. Replacement of old equipment is necessary to strengthen the community's ability to deal with large accidents and natural disasters where different agencies must cooperate. The network is in full operation in parts of Norway and a country-wide build out will be completed by end of 2015 (Directorate for Emergency Communication 2013). Nødnett is built to be resilient in order to meet the needs of the emergency services, and the network provides monitored, secured and robust communication. Users must have TETRA[1] radios approved to work with Nødnett. Talk groups are set up internally within the agencies and in groups in common with other emergency services. Only those actively given access to the individual talk groups can listen in. It is also possible to send and receive text messages and small amount of data.

5.1.6. Learning

To many firefighters and agency administrators in the US forest service, the word “accountability” has become synonymous with “punitive actions” (Wildfire 2013:4). Owning mistakes and sharing lessons learned from an accident can have career-ending decisions. This is not a good environment to share experiences.

[1] TETRA, Terrestrial Trunked Radio, is a mobile radio system for emergency and public safety agencies.

In order to change this environment several tools have been developed in the US Forest Service to capture relevant information and create a more open environment. They use the Facilitated Learning Analysis Process (FLA). Here are some of the principles the FLA process is built upon which are meant to promote sharing of information (Wildfire 2013:4):

(i) Any employees (at any level) perceive, anticipate, interpret, and react to risk is systematically connected to conditions associated with the design, systems, features, and culture of the workplace.

(ii) "Safety" is defined as the reasonableness of risk. A feeling. It is not an absolute. It is personal and contextual and will vary between people within identical situations based on expected outcomes.

(iii) Mistakes, errors, and lapses are normal and inevitable human behaviours. So are optimism and fatalism. So are taking shortcuts to save time and effort. So are under –and overestimating risk. In spite of this, our work systems are generally designed for the optimal worker, not a normal one.

(iv) All successful systems, organizations, and individuals will trend toward efficiency over thoroughness (production over protection) until something happens (usually an accident or a close call) that changes the perception of risk. This is what makes them successful.

These selected principles convey that within broader crisis management agencies there are still individuals that base their actions on how they perceive risk and safety. This supports the idea that everyone has something valuable to share and the importance of sharing and exchanging experiences is vital to create lessons learned.

6. LESSONS LEARNED AND BEST PRACTICES IN CRISIS MANAGEMENT OF FOREST FIRES

"Information is the lifeblood of safety. We must let it flow. If we punish employees for actions that, in perfect hindsight, appear to be errors or mistakes, we may (or may not) stop them from making errors or mistakes. However, it will definitely stop employees from sharing with management how they make sense about which rules are relevant, and how they make the trade-off decisions between production and safety". (Wildfirelessons.net 2013:7).

This chapter will explore and systematize the findings from the ELITE workshop on forest fires in Weeze in April 2014 and questionnaire with key informants in relation to the lessons learned identified in the literature review in chapter 5. This chapter constitute the main findings form the group discussions based on the scenario case presented (see section 3.4 for the scenario approach used in the workshop). Secondly, best practices related to learning, competence, technical equipment and interoperability will be presented.

6.1 Findings from workshop and the questionnaire

6.1.1. Findings from the workshop concerning sharing of best practices and lessons learned

It was noted by the experts that there are already several CoPs within the disaster management community in Europe. However, all these communities function differently which makes it difficult to share practices between CoPs.

Also many of the CoPs have websites in their own language. This is a challenge as end-users at different levels may have difficulties in reading documents in English. Thus, the *language barrier* to sharing was noted by several experts. In a crisis situation across borders, language barriers may have a negative effect on the level of interoperability in a crisis situation.

Another challenge to share lessons learned and best practices between fire agencies at an international level are the possible *legal restrictions*. This is especially the case if something went wrong as it might be sensitive (cf.US Forest service). Interestingly enough, it was noted by the experts that incidents when something went wrong are often good scenarios to learn from. However, experts noted that actors would want to be viewed in a positive light, i.e. that everything went as planned. This can restrict the sharing of experiences.

During the workshop it became apparent that experts/first responders tend to focus on technical issues/machines in their presentations. The focus was on *technological transfer.* This is very positive, but there are other areas where one share practices in terms of organization and processes.

Finally the experts, supported by secondary literature, note the difficulties to share best practices as one *lacks proper structures* to do this. In order to share one must use extra time in writing additional elements or translate the original document in order to upload it on the web. Experts and operationals must therefore do this in their spare time.

Using scenarios is a good approach to trigger interesting disucssions. However, several participants in the forest fire workshop were not used to assess problems and lessons learned

by using a a scenario approach. Therefore it was essential and necessary to obtain more information from the CoP after the workshop. Therefore a questionnaire was sent out shortly after the workshop.

6.1.2. Findings from the questionnaire

The experts who answered the questionnaire consisted mainly of first responders. The first question the respondents had to answer was in which level they worked. The respondents could choose between governmental employee, educational staff, advisor/researcher, operational level (strategic command) and first responder (tactical level). Nine other questions were posed relating to learning and best practices in the three phases of crisis (pre-crisis, during a crisis and post-crisis). The questionnaire (see Appendix A) was sent to participants in the ELITE CoP who are experts in the field of forest fires. We received responses from experts in Poland, Italy, the Netherlands, Norway and Finland.

Interoperability challenges
It seemed that several respondents argued that media played an important role. It was noted that it was very important to deal with media in a proficient way. If the incident has potential to become big, one should use resources and time in the beginning of the crisis to inform the public. One respondent argued "*Sometimes, it is difficult to cooperate with mass media, which does not follow our procedures taking pictures or filming forbidden images".*

Other respondents at tactical level argued that every crisis is a challenge as "*we rescue different people, we cooperate with different authorities on different levels and we meet difficulties on our way, for example, people do not want to leave their houses during floods or there is a problem to provide some temporary shelters for people who lost their houses".*

Other respondents argued that one should create "*National Incident management teams to be able to deal with large incident better*" (Operational level (strategic command)).

Through preparation one can overcome interoperability challenges. One advisor noted how different educational models for children were conducted to raise awareness on fire risks and to share information about preparedness and prevention. "*In the previous years we produced a lot of materials (brochures, role plays, cartoons, publications, etc.) so we are thinking to organize this material to create a valid support for teachers and Volunteers during the meeting on civil protection teams*" (advisor/researcher). Another measure was to have educational programmes for the volunteers in Civil Protection; "*there is a document that identify the formative contents that volunteers must learn in a classroom, a practical test about tools and materials of civil protection is done and at the end there is a final examination*». The volunteers that pass all the tests receive a certification of "Basic Course of Civil Protection". This is obligatory in order to register as Operative Volunteers in this specific region (advisor).

Learning before an incident (pre-crisis phase: mitigation, prevention, preparation)
The first responders at tactical level have practical and theoretical tools to prepare for a crisis. It can range from workshops, table tops exercises and scenarios. It seemed that practical learning was most wanted. "*The more practical exercises we have the more skills we gain, which can be used during real actions".*

A respondent at operational level (strategic command) noted how table top exercises were used to prepare for large incidents. They also conducted scenarios in cooperation with the forest owners. This help to decrease interoperability challenges. An advisor noted that in their country they prepare the citizens and volunteers. Informative campaigns are conducted to sensitize people towards respecting the nature. This happens every year at schools and also in the

municipalities. The focus of the informational campaigns is the importance of forest fire prevention. Every year volunteers must be involved in activities of fire watching; "*Inside the forest some platforms were built which the volunteers can use in order to patrol the forest and observe the landscape. When the volunteers see smoke they call the Operative Room in order to start immediately the operations. There are also mobile teams that go around the forest by car*" (Advisor/researcher). The advisor noted that some volunteers are even involved in extinguishing activities together with firefighters and forest rangers. Social media is used and the advisor argued that it "*reinforces the process of dissemination of the culture of Civil Protection and it is also used to inform the citizens about events related to civil protection and resilience (prevention and preparation phases)".*

An advisor/researcher noted the importance of defining the correct role of the actors involved. The advisor exemplified by using two organizations that combat forest fires; firefighters and forest rangers. Through emergency planning in the pre-crisis stage they had successfully managed to define the correct role and the competences of both organizations.

The advisor noted how they had also created new terminology to capture and specify the events that could be critical in terms of procedures of coordination; the term is "urban rural interface fire". The advisor argued that "*when a fire happens in the city (fire in a house or buildings, etc.) usually the competence concerns to the firefighters, when the fire happens in the forest usually the competence concerns to the forest rangers. But when the fire is on the border between the city and the forest there may be some problems and for this reason we adopt the emergency planning, in order to optimize the resources and to facilitate the operational actions*" (advisor/researcher).

The advisor also mentioned that a data base of burned areas had been developed in order to know and classify the surface where the fire happened. This can help in creating and defining indicators of risk.

Learning during/right after a crisis situation (crisis, response, recovery)
During the crisis it seemed that respondents at tactical level had to be attentive towards the development of the crisis and the different procedures that must be followed. One respondent at the tactical level argued that "*Sometimes during crisis situations we learn how to use the same equipment in different situations so that it can have different applications".* Another respondent at tactical level also noted the importance of experiencing a crisis; *"Every crisis situation teaches us a lot in terms of equipment and competence, because we behave differently according to the situation, people injured, victims, and other conditions".*

One respondent who was operational level (strategic command) noted that after incidents they had implemented a different type of equipment. This was based on their own experience as well as ideas from France and Portugal. "*Learning related to brains/competence is the implementation of incident management team in our region, to assist local Fire Chief in large incidents".*

Learning after an incident (post-crisis phase - analysis)
Most respondents at tactical level argued that debriefings are very good in relation to learning and improving equipment, hands and competence. Sharing the experience with colleagues was mentioned; *«We can share opinions on different aspects, methods, steps during our mutual actions and find best solutions".* Some respondents argued that creating a summary of the incident with the other colleagues who had participated *"helps us in understanding problems, difficulties and to eliminate them during next rescue operations".* However, some responders argued that after a crisis one must overcome the stress experienced in relation to the crisis. Stress management after a crisis is important, because it is difficult to learn if one is stressed

about what happened. "*After a disaster we often forget about the recovery stage, which is so important both for people who experienced the fire and for us, firefighters. We have to learn to return to our normal emotional condition and people who overcome the disaster have to build their new life forgetting about the past".*

What happens after a lesson is learned?
Respondents at tactical level argued that if a lesson was learned one should *"inform the fire chief who is in the charge of sharing and let him share the information among the other firefighters".* This is because "*I don't have a power to incorporate it in procedures, I only inform my chief and other firefighters about lessons learned".* A respondent at operational level (strategic command) argued that normally lessons learned are incorporated in procedures. A governmental employee noted that he *"encouraged others, who are responsible, to implement the lesson learned. And I will check if they did so".*

An advisor argued that "*A lesson learned becomes so after that a relevant number of people certified the importance of the arguments. I think that after this step it is necessary to standardize the lessons learned so that a large numbers of organizations can use it, and secondly it is necessary to inform all the stakeholders involved in the same process*" (advisor/researcher). Writing briefs and papers might be useful, but the advisor maintained that a web-based document would be most fruitful. "*The lesson learned needs to be implemented in the procedures of the organizations and after this; there will be a process of review in order to improve the contents. For this reason a web based document is better, with the possibility to interact in real time with the documents*" (advisor/researcher).

6.2 Best practices

This section will include some best practices related to learning, personnel, technical equipment and interoperability as the topics were repeatedly mentioned by the CoP members in the workshop.

6.2.1. Best practices related to learning

"Hindsight bias is the chief saboteur of any accident investigation. Interviewers should remember their highest objective, to be able to describe how interviewees (the people they are interviewing) developed their understanding of the situation—and then made sense of their choices at the time, and in context."

Fire Operations Risk Management Council U.S. Forest Service (Wildfirelessons 2013:16)

Wildfirelessons (2013:9) note that once the employees, families, and co-workers are cared for, the administrator should ask those involved to separately take a moment to jot down notes of what they remember as significant events, observations, decisions from the incident.

Personal note-taking should occur as soon as possible after the event—if possible, *before* employees discuss the accident with other employees (Wildfirelessons 2013:9). The purpose of this is to "capture their thoughts and perceptions as close as possible to the time when the event occurred". This is because memories will change as sensemaking evolves. Therefore employees will be asked to *write their notes in brief "bulleted" form* and to refrain from building a story or make sense of what happened as much as they can. It is further noted that one should assure employees that they will get a chance to tell their story later. What are needed are bullet statements of memories that might get lost later. Remind employees that these notes are their own property and will not be collected or read by anyone else (Wildfirelessons 2013:9). These notes are good when having debriefings later as one can read what one thought immediately

after the crisis. These personal notes are a good departure point related to learning from past incidents as hindsight often can obscure the details from the incident.

Sharing can also be argued to be a type of learning in itself. Gary Klein (author of *Sources of Power: How People Make Decisions*) argue that *"We like to hear good stories retold. What is more interesting is our need to tell stories, again and again and again. Each telling helps us understand more about the lessons embedded in the story".* According to Wildfirelessons (2013:33) effective storytelling is the most powerful teaching tool we have to convey the wisdom and experience gained from living through an incident. One can argue that being able to share your story moves Lessons Learned into the vicarious experience of Lessons Lived (ibid). The Facilitated Learning Analysis Process (FLA) includes storytelling where the narrative is a factual account of what occurred as told from the perspective of those most directly affected.

Thus, all sorts of debriefing and sharing between people involved in an incident are important. The ELITE workshops and the living document attempt to focus on this process; because sharing is a type of learning in itself. Sharing with the broader COP increases the conscientation process among the actors. The workshops therefore functions as a platform for sharing experiences and learning. Social media is used in ELITE to be able to spread information fast and to create an interactive context that leads to a better environment for learning.

6.2.2. Best practices related to personnel (competence)

Experiential learning most often happens with people who work with handling different types of emergencies and who follow contingency plans or Standard Operating Procedures (SOP). Thus, professionals and experts working with the crisis management dealing with wildfire will most often have much more experience than any of the political leaders. Many of the fire brigades at the forest fire workshop in Weeze noted that after a crisis (i.e. the post-crisis phase) the people involved in managing the crisis would meet and discuss the process, response and share experiences. This is a vital part in translating memories into lessons and is a good example of *experiential learning*.

Not all people working in crisis management has been exposed to large scale crisis, but sometimes one can learn *indirectly* from others. Some fire brigades noted how they managed to get the crisis log/minutes from other fire brigades who had experienced large scale fires. Then expert and professionals could use these minutes and discuss how they would have handled the situation and compare it with the fire brigade who had actually experienced this situation.

An example of *explanation based learning* is from Operation Rudy mentioned in section 3.3. An investigation was launched after the fire, but during the fall of 1994 the prosecutor's office in Katowice closed the investigation concerning the forest fire in Kuznia Raciborska. The reason why the fire was ignited was believed to be mechanical sparks generated by friction, when passing train started to decelerate. The Police attempted to find suspects for arson, but did not find any. The conclusion was that the involved fire prevention agencies in the forest fire worked the best way they could have done as regulations were obeyed and the response was appropriate to the size of the crisis. There were no charges for officers in charge of fire operations. They assumed, their actions were the only reasonable at the time of fire. However, the prosecutor stated, some fire prevention regulations were not obeyed by the Polish Railways. The reason why this forest fire became so uncontrollable and become a massive crisis was due to:

(i) the condition of the forest,
(ii) Dry wooden and other rotting material (forest fuels),

(iii) Extremely disadvantageous meteorological conditions (droughts, impetuous wind) and
(iv) the lack of natural water sources paralyzing fire operations at some point during the crisis.

Federation of the Fire-Fighters of the District of Aveiro (FBDA) in Portugal wrote in their field report after Exchange of Experts that they had learned "The importance of investing in young fire-fighters academies/structures" from the experts from several countries (France, Germany, Poland, Czech Republic and Portugal). This is an example of learning from others which would lead to capacity and competence building among personnel in management.

6.2.3. Best practices related to technical equipment

What was noted during the forest fire workshop is that experts within the field of wildfire management like to focus on getting access to newer equipment and technological innovations. For example one respondent at operational level noted that

"*After several incidents of forest fires we noted that a different set of pumps were needed. We therefore began looking for alternative pumps that we could have in our fire station. However, we had little knowledge of these new types of pumps as they are not on the market in our country. We therefore contacted fire stations in Portugal and Spain and went to visit them and ask them about positive and negative features of this type of pump. The Portuguese firemen shared their experience of using these pumps in forest fires. Based on their advice we contacted the producers of these pumps and we managed to alter and improve the quality of the pumps. Afterwards the improved equipment was sent to Norway and is being used*" (respondent at operational level).

This is an example of *professional competence and learning*. This implies that during and after the crisis new expertise and technology is created to handle a similar future crisis in a better manner. This means that one detects a knowledge gap in specific areas.

6.2.4. Best practices related to interoperability

Poland has experienced several large forest fires and also provided assistance to other countries during forest fires. Polish firefighters who participated in the operations identified several lessons that could make the next operations more successful.

Before the crisis one should check the functionality of the hoses because it is important to provide maximum number of hoses. It is also important to conduct workshops concerning organizing and compiling documentation which should be prepared, procedures related to the organization of the extinguishing, conditions of means and forces selection according to certain type of disaster and threat.

During the crisis one should provide buses in order to transport firefighters. This will increase the comfort of the trip and decrease the number of firefighters going by fire truck. Then firefighters can rest and gather energy before they arrive at the scene. The company commanders should be equipped with a portable GPS device and they should be trained both in terms of its use and interaction of GPS with maps. A camera with the function of recording GPS coordinates is an important device which should be used during the action. The group should also include a doctor who will have a function of medical protection of the group.

After the crisis one should have a detailed analysis of activities as well as final report should be compiled after the completed action. This is an example of attempting to increase *experiential learning.*

An example of best practices in relation to interoperability is the organization of volunteers. Skien Fire Brigade in Norway noted that lessons learned from Portugal and Spain were that one should organize volunteers into smaller and more competent teams. For example Skien Fire Brigade went from 1500 volunteers without regularly practice and trainings, to 75 people who now are organized in three groups.

6.3 Challenges related forest fires and different types of learning

An identified problem area is interoperability especially relating to different terminology between national agencies. In the literature review there were several lessons identified related to the challenge of interoperability. The lessons identified are examples of *experiential learning.* This is when one has experienced direct exposure to a crisis and has subsequently developed insight about what caused the crisis and how the crisis management worked. The DSB attempted to overcome interoperability challenges between different agencies by implementing an Incident Command system. DSB argued that it will lead to common guidelines concerning command and control and better the conditions for management of large scale crisis (DSB 2008:41). Increased supervision of vulnerable municipalities with large forests (DSB 2008:42), as well as closer cooperation with the civil society and volunteers (DSB 2008:52) were identified. DSB (2008:67) noted that there is little experiential based learning from forest fires as systematic learning or review from previous crisis on how the different fires were managed lacks. Such systematic reports would have been a good basis for sharing experiences and developing strategies for mitigation.

From the questionnaire several respondents argued that one had problems with the mass media. Often the mass media would not follow the instructions of the first responders and walk into restricted areas. Another issue is that a lot of time is used to speak and deal with the press, rather than to focus on the mission. Therefore only few people (Fire chief etc.) deal directly with the media. This identified lesson is an example of *experiential learning.*

Xanthopoulos (in Forest Europe 2010:22) argues that one lacks of fire statistics and that one has fragmented and incomplete data on a regional level. There have been serious efforts both within countries and at the EU level to address the forest fire problem, but so far the results are not satisfactory (ibid). The focus has been on creating a common database with information and statistics. This can be argued to be an attempt *explanation based learning* as one has “rational-scientific search for the causes of failure and the effect of response” (Boin et al. 2005:117). Forest fire statistics have been used by experts to analyze the fire problem and determining how to best manage it. He noted that in order to have comparable and comprehensive forest fire data, a harmonized methodology must be developed and disseminated for use by the European Countries (Forest Europe 2010:22). This is echoed by others who argue that there are limited data on forest fires as impact assessments of forest fires are often incomplete, efficacy of prevention measures is almost never conducted, and total costs of prevention policies are unknown due to fragmentation of measures and budgets across different levels and actors. Improving the information sources could support future choices in forest fire prevention as an integral part of fire management.

Several experts have voiced that one lacks information concerning fire weather and information concerning the availability of equipment. This is an example of *technical and competence based learning.* One lacked data on specific fire weather factors. Thus one decided to create a Forest Fire index. These indexes build on the competence of the meteorological institutes and related to fire weather. This can be used as an instrument reporting on elevated risk of forest fires (DSB 2008:56). Other examples of a knowledge gap and how one attempts to bridge this is the Norwegian National Resource register (NARRE); the digital register that contains information

about all the available rescue and emergency resources.The establishment of a new joint digital radio network for emergency and public safety agencies is also an example of technical learning from a previous crisis (Directorate for Emergency Communication 2013).

7. CONCLUSIONS

This report has *gathered and systematized knowledge on* forest fires. From secondary literature which consisted mainly of scientific papers and evaluation reports it became clear that there was a strong link between forest fires and climate change. Research to date indicates that both the incidence and severity of forest fires will increase dramatically. It was noted that there will be:

- *longer fire seasons,*
- *larger areas will become burned,*
- *shorter fire–return intervals,*
- *a shift to a lower forest age-class distribution*
- *a "positive feedback loop" (more forest fire leads to greater terrestrial loss of carbon to the atmosphere, which feeds into greater global warming and again more forest fires).*

The importance of creating a good environment for sharing experiences and thereby learn from these has been stated from several CoP experts, both in the workshop and in the questionnaire. The FLA process, developed and used by the US Forest Service, is a good example of how to meet these challenges and promote sharing of information. Another example of how one can achieve learning, is the experiental learning model (fig.1) with different steps, developed by a Working group on experiential learning in the Norwegian Fire and Rescue Services. For sharing and learning purposes, we recommend to look into this model.

Through workshops (group discussions with the CoP), literature review and questionnaires we have managed to *identify the most relevant lessons learned from forest fires.* Below is a table summarizing the lessons learned categorized according to topics defined by the authors when systematizing the results from the workshop, literature studies and questionnaire (table 2). The source is also indicated.

Topic	Lesson learned	Source
Learning; sharing	*Language barriers* to sharing lessons learned between different European operationals is a problem and in a crisis situation across borders, language barriers may have a negative effect on the level of interoperability.	(CoP)
Learning; sharing	Possible *legal restrictions* to sharing lessons learned and best practices between fire agencies at an international level can restrict the sharing of practices.	(CoP)
Learning; sharing	The operationals lacks *proper structures* to share lesson learned. To share the operationals must use their spare time to write additional elements or translate the original document in order to upload it on the web.	(CoP)
Interoperability	Difficult to cooperate with the media, one must plan how to deal with media in a proficient way before the crisis.	(CoP)
Knowledge	It is important to have educational models for children to raise awareness on fire risks and to share information about preparedness and prevention.	(CoP)
Knowledge	Educational programmes for the volunteers in Civil Protection where they have classroom education, a practical test about tools and materials of civil protection, and a final examination where the	(CoP)

	volunteers that pass receive a certification which obligatory to register as Operative Volunteers.	
Learning before an incident	More practical exercises are needed for the fire operationals to gain skills, which can be used during real actions.	(CoP)
Learning before an incident	Table top and scenarios exercises in cooperation with the forest owners can help to decrease interoperability challenges.	(CoP)
Learning before an incident	Inside the forest platforms must be built so that the volunteers can patrol the forest and observe the landscape. When the volunteers see the smoke they call the Operative Room in order to start immediately the operations.	(CoP)
Learning before an incident	Important to define roles between firefighters and forest rangers in emergency planning in the pre-crisis stage.	(CoP)
Learning before an incident	Create new terminology to capture and specify the events that could be critical in terms of procedures of coordination in an urban-rural-interface fire.	(CoP)
Learning before an incident	Data base of burned areas must be developed to classify the surface where the fire happened. This can help in creating and defining indicators of risk.	(CoP)
Learning during/ right after a crisis situation	Learn to use the same equipment in different situations so that it can have different applications.	(CoP)
Learning after an incident	Debriefing, sharing information, creating a summary of the incident are very good in relation to learning and improving equipment, hands and competence.	(CoP)
Learning after an incident	Stress management after a crisis is important, because it is difficult to learn if one is stressed about what happened.	(CoP)
Learning after an incident	Standardize the lessons learned so that a large numbers of organizations can use it. It is also necessary to inform all the stakeholders involved in the same process.	(CoP)
Learning; Strategic decision-making	Local fire brigades often requires more resources than they have. Therefore they must be strategic when a forest fire occur; when the Fire brigade receives an emergency call they would (i) use their local knowledge and create a worst case scenario, (ii) would contact relevant agencies and fire brigades from neighboring municipalities who would immediately send fire trucks. However, if it was not as bad as one expected one could call off the additional help. The Fire chief noted that it is better to call one too many times, than not make the call and suffer the consequences (better safe than sorry).	Interview with Skien Fire brigade (2013)
Knowledge	Nowadays forest fires are linked to modern models of life, increased mobility, tourism and recreational activities which increase the number of visitors in the forest.	Firesmart (2010)
Knowledge	*Human factors* triggering wildfires are most dominant in Europe (arson, sparks from railway, equipment, power line arcs or discarded cigarettes). This is something we can prevent.	Firesmart (2010)

Knowledge	Forest fuels (shrub layer, grass layer, litter) in the canopy of the trees may accumulate over time. This creates "ladders" so that the wildfire can climb up in the tree tops. How the trees are situated in the spatial arrangement may therefore influence the availability of 'fuel' and how the fire can spread.	US Forest Service (2003)
Knowledge	The fire activity in the Euro Mediterranean countries (EUMed) have been changing due to industrialization and that people have migrated from rural areas.	FUME (2014)
Knowledge	Fires do not burn equally all areas in a landscape and positive feedbacks driven by fire have been documented across Southern Europe. It is important to understand how the positive feedbacks works to "prevent certain areas entering into fire-driven degradation loops".	FUME (2014)
Interoperability	Few common and harmonized definitions with regards to the prevention of forest fires in Europe.	Forest Europe (2010)
Interoperability	Greece, Norway, France and UK have implemented Incident Command System with common guidelines on command and control. This will better the conditions for management of large scale crisis between different agencies.	EU-exchange of experts; DSB
Interoperability	Fire departments should in their contingency planning have contact and enter into agreements with relevant people with local knowledge from the civil society that can assist during forest fires.	Interview Skien Fire brigade (2013)
Interoperability	To facilitate involvement of volunteers they must receive funding which reaches local actors (local multipliers).	Forest Europe (2010)
Preventative measures	Prevention should focus on maintaining forest vegetation to safe levels, developing safer Wildland and Urban Interface areas, and preparing sophisticated pre-suppression plans that well-trained and equipped firefighting forces can apply effectively.	Forest Europe (2010)
Preventative measures	Prescribed burnings in the non wildfire season carried out by fire proffesionals to prevent possible future fires.	Forest Europe (2010)
Preventative measures	Prevention schemes should include *(i) maintenance of tracks, (ii) firebreaks, (iii) water points, (iv) fuel management and (v) monitoring for early detection.*	Forest Europe (2010)
Preventative measures	The need to put resources into active management of the landscape and to consider how the market could be utilized for promoting forest management.	Forest Europe (2010)
Preventative measures	Forest fire statistics are important and necessary tools for analyzing the fire problem and determining how to best manage it.	Forest Europe (2010)
Preventative measures	Municipalities with significant risk of wildfire must be prepared by (i) being able to facilitate a large number of troops, more resources and management of a forest fire over time. (ii) The municipality must have binding agreements with other fire departments, forest owners, and other people with other resources. (iii) The municipality must have adequate supply of equipment, maps etc. and (iv) a practiced fire management crew.	DSB (2008)

Preventative measures	Meteorological institutes can play a role in creating a forest fire danger index which can be used as an instrument reporting on elevated risk of forest fires.	DSB (2008); UK Fire Service (2011).
Recovery	Our current knowledge on recovery from forest fires is limited, each large wildfire is an opportunity to conduct studies and expand our knowledge about post-fire management.	Pacific Northwest Research Atation (2007)
Equipment	Development of a new multi-function tool made of hardened steel with a hard wood shaft. The tool is very versatile and can be used to pick, drag, cut and dig vegetation as well as cut wire fencing.	UK Forest Service (2001).
Equipment	Replace the old fire extinguish equipment. Older air cooled fire pumps stopped during the Froland fire in Norway (2008) this decreased the security for the firefighter who had reduced protection.	Interview with Skien Fire brigade (2013)
Learning	Facilitated Learning Analysis Process (FLA) used to promote sharing of information.	Wildfire (2013)

Table 2: Summary of relevant lessons learned gathered from the ELITE CoP

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ANNEX A QUESTIONNAIRE

Questionnaire concerning Lessons Learned on Forest Fires

(1) How do you describe yourself?
- o Governmental employee
- o Educational staff
- o Advisor/researcher
- o Operational level (strategic command)
- o First responder (tactical level)

(2) Do you have any best practices related to learning before an incident (pre-crisis: Mitigation, prevention, preparation)? In terms of (i) equipment, (ii) hands, (iii) brains/competence.

(3) Do you have any best practices related to learning during/right after a crisis situation (Crisis: response, recovery)? In terms of (i) equipment, (ii) hands, (iii) brains/competence.

(4) Do you have any best practices related to learning after an incident (post crisis stage-analysis)? In terms of (i) equipment, (ii) hands, (iii) brains/competence.

(5) Are there any challenges related to interoperability between actors within the crisis management (strategic, operative and tactical) and other actors?

(6) What do you do when a lesson is learned? (Inform, write a paper, and incorporate in procedures? Etc.)

(7) Do you use social media?

(8) Do you have educational models/programmes/certification programmes

(9) Did you take any best practices home with you after the workshop in Weeze?

(10) Rate your level of interest/engagement from (0-5) in relation to:
- (a) power point presentation of the Scenario
- (b) Discussion groups
- (c) Plenary discussion
- (d) individual presentations

ANNEX B ABBREVIATIONS

CoP	Community of Practice
DSB	Norwegian Directorate for Civil Protection
ELITE	Elicit to Learn Crucial Post-Crisis Lessons
ESA	European Space Agency
EU	European Union
EUMed	Euro Mediterranean countries
FAO	Food and Agriculture Organization of the United Nations
FFI	Norwegian Defence Research Establishment
FBDA	Fire-Fighters of the District of Aveiro
FLA	Facilitated Learning Analysis Process
FUME	Forest fires under climate, social and economic changes in Europe, the Mediterranean and other fire-affected areas of the world
GAUF team	Group Analysis and Use of Fire teams
IPCC	Intergovernmental Panel on Climate Change
NARRE	Norwegian National Resource register
NASA	National Aeronautics and Space Administration
NGO	non-governmental organizations
OIC	Officer in charge
RUI	Rural-urban interface
SOPs	Standard Operating Procedures
TETRA	Terrestrial Trunked Radio
WUI	Wildland and urban interface