# Hazard Specific Risk Assessment: Climatological

## 1 - Wildfire Hazard and Risk Assessment

*Key words: wildfires, wildfire hazard, risk assessment, wildfire exposure, wildfire vulnerability, risk mitigation, wildland-urban interface*

Globally, the occurrence of vegetation fires is common in all continents. Natural vegetation fires have been documented since prehistoric times and have significantly shaped the composition and dynamics of some ecosystems including forests and open landscapes. Since the beginning of land cultivation by early humans the use of fire contributed to the evolution of humanity and the formation and productivity of cultural landscapes. Today the vegetated area annually affected by fire globally may range between 300 and 600 million hectares (3-6 million square kilometers).[1] While some natural ecosystems and land-use systems are dependent, adapted or tolerant to fire, other ecosystems are highly susceptible. With increasing human population and expanding land-use change the interfaces between vegetation fires and vulnerable human assets are becoming more abundant, critical and conflicting. Furthermore, scientific evidence reveals that the indirect impacts of vegetation fires have significant impacts on the environment and society. Most importantly the fire emissions (gas and particle emissions) influence the composition of the atmosphere and thus on global climate as well as on human health and security.[2]

Wildfires in wildland-urban interfaces (WUIs) are serious threat to communities in many countries worldwide as they can be extremely destructive, killing people and destroying homes and other structures, as was the case in California in 2003 and 2007, Greece 2007, Australia 2009, Israel 2016 and Chile 2017.[3,4,5,6] According to fire fatalities database of the Global Fire Monitoring Center an average of 297 deadly fatalities caused by wildfires (both civilians and firefighters) per year have been reported globally between 2008 and 2015.[7]

Wildfires also affect the ecological functioning of many ecosystems as they partially or completely burn the vegetation layers and affect post-fire soil and vegetation processes such as soil erosion, debris flow, flooding and vegetation recovery.[8]

FIGURE 1 – Wildfire burning at the Wildland-Urban Interface



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In addition to global impacts, fires also have important local impacts, which are commonly associated with fire frequency and intensity, and imply loss of life and infrastructure, soil degradation, and changes in vegetation and biodiversity. These changes can also affect ecosystem services such as food production and stocks of fresh water or wood products. This process particularly affects tropical rain forest, which has little adaptability to fire.

## Tsunami hazard assessment

The term "hazard" is considered a process, a phenomenon or a human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Wildfire hazard is usually computed or expressed as potential fire behavior (e.g., fireline intensity) or fuel physical and chemical properties (e.g., loading or biomass). Land managers and firefighting officials are required to consider the wildfire hazard potential in order to identify local wildfire threats and assess the risks to communities, educate and motivate homeowners and landowners and increase community involvement with wildfire awareness and preparation, assist land managers and planners in making appropriate decisions about land management and development in fire prone areas and assist local fire protection districts in pre-attack planning.[9] The spatial estimation of wildfire hazard is often a difficult task due to the complexity of fire occurrence across multiple spatiotemporal scales.[10] The dominant factors determining wildfire behavior, or the fire spread and intensity in space and time, are fuel availability and fuel conditions, topography, atmospheric conditions, and the presence of firefighting. Wildfire hazard has been estimated by a variety of approaches considering some or several of these drivers, including expected fire behavior, spatial arrangement of fuels, topography variables, as well as expert knowledge.

## Wildfire Risk Assessment

Wildfire risk is the product of the likelihood of a fire occurring, the associated fire behavior, and the fire's impacts. Wildfire risk mitigation is achieved when any of the three parameters (likelihood, behavior, and/or impacts) are reduced. Wildfire risk has been defined in a variety of ways. However, most of them refer only to wildfire likelihood and behavior and do not take into consideration the expected fire impacts.[11,12,13,14]

Recent advances in landscape wildfire behavior modeling have led to a number of new tools and approaches for applying risk frameworks to wildfire management problems which allow land managers to estimate all of the primary wildfire risk components (likelihood, intensity, and impacts) to a number of high-value resources located within forest stands and lands. Computer models can now perform spatially explicit fire simulations over heterogeneous fuels and map wildfire behavior characteristics across large landscapes. These approaches have been recently incorporated as a key element for assessing risk in wildfire management in the United States[15] at national scale and in Euro-Mediterranean countries at regional scales.[16] Furthermore, they are used to support tactical and strategic decisions related to the mitigation of wildfire risk, the post-fire impacts, the forest carbon pools estimation, the forest restoration, and the post-fire soil erosion.

## Wildfire Exposure and Vulnerability

Wildfire exposure defines the situation of people, infrastructure, housing, production capacities and other tangible human assets located in wildfire-prone areas.[17] Wildfire exposure is simply the spatial juxtaposition of wildfire likelihood and intensity metrics with the location of Highly Valued Resources and Assets (HVRAs) found in a specific area. Wildfire vulnerability expresses the potential damage from wildfires and it may be

defined as: "The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging impacts of a hazard".[18] Assessment of vulnerability to wildfire should consider the expected damage caused by wildfire, which is a critical part of an integrated wildfire risk assessment.

The combination of wildfire exposure, vulnerability and risk assessment has been widely used as an integrated framework for holistic fire management in many fire prone parts in the world. [19202122]

Recently, the concepts of wildfire risk transmission and human-natural systems have been also studied in the United States in order to create assessment methods that can advance concepts for cross-boundary wildfire risk governance and facilitate the development of more effective policies and practices for fire-prone landscapes.[2324]

## Risk Assessment and Use in National DRR measures

A critical component of effective wildfire prevention policies and strategies is a long-term wildfire risk assessment, based on robust methods accounting for spatial and temporal nature of wildfire risk.[25,26] At local scale, such wildfire risk assessment could be used for areas to be treated for wildfire risk reduction, fuel treatment practices implementation, fire towers and water tank construction. This information is extremely useful in implementing efficient preventive strategies and measures, since fire prevention is not only preferable but also a cost effective way to manage forest fires when compared to fire fighting and suppression. Availability of information on wildfire risk assessment at regional scale supports optimal allocation of fire-fighting personnel and the protection of critical infrastructure.[27] Holistic wildfire management and implementation plans at landscape level should be based on wildfire risk scenarios which take into consideration wildfire danger warning systems coupled with physical and socioeconomic parameters.[28] When it comes to global scale wildfire risk assessment, the focus is shifted towards identification of supra-national patterns of similarities and differences, development, coordination of effective prevention and response mechanisms, identifying areas where more detailed risk assessment models should be implemented, as well as facilitating research on the context of climate change. Global wildfire risk assessment also is necessary for comprehensive wildfire protection and policies development.

## A Regional Case Study

Wildfires constitute a severe threat to cultural heritage sites, particularly in countries where the majority of cultural heritage and archaeological sites are covered with vegetation or situated close to forests and other flammable vegetation. Reports of damages caused by wildfires on historical sites are becoming more frequent and alarming. Wildfire events in recent years have threatened Natural UNESCO World Heritage Properties in recent years, including Garajonay National Park (Canary Islands, Spain), Nea Moni Monastery (Chios Island, Greece), Ancient Olympia (Greece), and Laurisilva (Madeira Island, Portugal).

In 2016, a regional wildfire risk and exposure assessment was done at Holy Mount Athos in Greece, a UNESCO World Heritage Site. This case study is an example of the use of satellite remote sensing and GIS for wildfire risk assessment at a regional and local scale (Fig.2).[29]

The special characteristics of the surroundings, the monasteries and their architecture, the relatively limited human activity, and the singular and isolated location of the peninsula have combined to make Mount Athos one of the most unique and important coastal landscapes in Greece and the Mediterranean area as a whole. Mt. Athos includes 20 monasteries and other structures that are threatened by increasing frequency of wildfires. Assessing wildfire risk and exposure enabled development and implementation of fire management plans for this region, supporting management of

its important cultural heritage. The study resulted in: i) development of detailed site-specific fuel models in a Mediterranean study area that are suitable for fire behavior prediction; ii) production of a detailed fuel-type map with the use of high spatial and temporal resolution remote sensing data processed through an object-based classification approach; and iii) generation of accurate fire risk and exposure maps in a fragmented landscape.

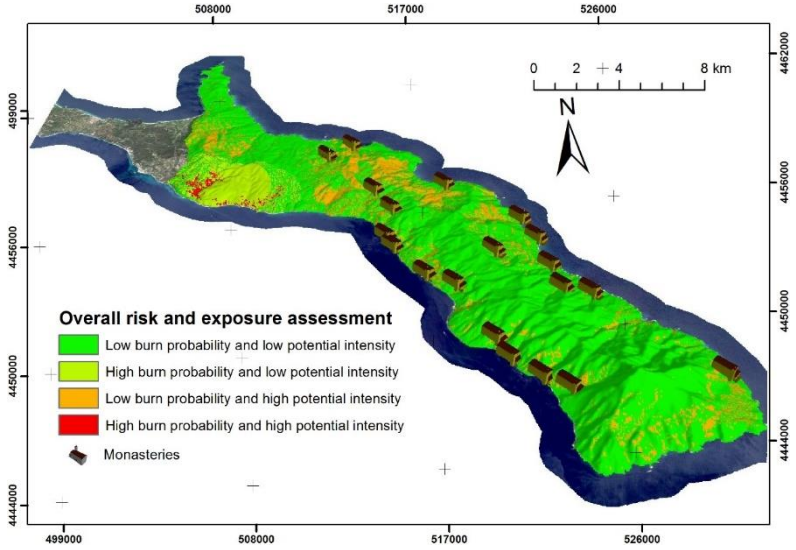


**FIGURE 1** – Fire risk and exposure assessment in Holy Mount Athos, Greece

## Resources for Further Information

Freely available software tools exist for simulating wildfire propagation and wildfire impacts at different temporal and spatial scales. Some widely-used models include BehavePlus, FlamMap, FARSITE, FOFEM etc. These models require appropriate skills, training and adequate knowledge on GIS and wildland fuel modelling to be used effectively. Most of these software and tools have been validated against prescribed fires and medium-low intensity wildfires. Relevant information about models and the software tools can be found through the Fire, Fuel, and Smoke Science Program (FFS) web portal.[30] ArcFuels is a streamlined fuel management planning and wildfire risk assessment toolbar implemented in ArcMap GIS software which creates a trans-scale (stand to large landscape) interface to apply various forest growth (e.g., Forest Vegetation Simulator) and fire behavior models (e.g., FlamMap).[31] Methods for enhancing capacities of local communities in wildfire disaster risk reduction are provided by numerous initiatives.[32]

The FireWise Community Program is a collaborative approach that encourages local solutions for safety by involving homeowners in taking individual responsibility for preparing their homes from the risk of wildfire. [33]

FireSmart is a Canadian initiative which provides to communities and individuals across Canada the information and tools they need to confront interface fire protection issues.[34]

The Global Fire Monitoring Center (GFMC) provides a global portal for wildland fire documentation, information and monitoring and is publicly accessible through the Internet.[35] The regularly updated national to global wildland fire products of the GFMC are generated by a worldwide network of cooperating institutions. Web-based information and GFMC services include:

- Early warning of fire danger and near-real time monitoring of fire events, including the Global Wildland Fire Early Warning System.[36]
- Interpretation, synthesis and archive of global fire information

- Support of nations and international organizations to develop long-term strategies or policies for wildland fire management, including community-based fire management approaches and advanced wildland fire management training for decision makers, especially in the prevention and preparedness of wildfire disasters.
- Serve as advisory body to the UN system through the coordination of the UNISDR Wildland Fire Advisory Group and the UNISDR Global Wildland Fire Network.[37]
- Emergency hotline and liaison capabilities for providing assistance for rapid assessment and decision support in response to wildland fire emergencies under cooperative agreements with UN-OCHA, Emergency Services Branch.[38]

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