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# FIRE PROTECTION OF INACCESSIBLE AREAS WITH A FOCUS ON PREVENTION

***Abstract:*** *Forest fires in inaccessible areas are a serious problem all around the world and often lead to catastrophic consequences not only for the areas affected by the fire but also for nearby agricultural and even residential areas. In addition, forest fires also pose a potential threat to tourism, which is one of the most important economic sector in developed countries, as large forest fires instill insecurity and fear among visitors. This paper examines the challenges and measures for protecting against forest fires in inaccessible areas, which are at high risk of fire due to global warming and adverse climate conditions. The number of forest fires is expected to increase by 50% by 2050, which requires improved safety measures and equipment. The consequences of fires include ecological, economic and social damage, while most fires are caused by human activities. The paper focuses on key factors that influence forest fires, such as meteorological conditions, vegetation types and accessibility of forest areas, and emphasizes the importance of preventive measures such as forest thinning, construction of access roads and vegetation planning that can slow down the spread of fires. Innovative methods such as 24-hour video and meteorological surveillance, drones with thermal cameras and fire spread simulators help in prevention and rapid intervention. The paper also highlights the importance of cooperation between local communities and farmers in fire prevention activities, and how these measures contribute to the development of tourism, agriculture and sustainable management of natural resources. The application of these systems of some area's has proven effective in reducing risks and damages, while the implementation of technologies such as video surveillance and simulations can further improve fire responses. The developed systems contribute to economic profitability and environmental protection, and provide many benefits for local communities.*

***Keywords:*** *fire prevention, forest fires, holistic fire protection*

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# 1. Introduction

Due to global warming—a worldwide issue that significantly affects even remote and inaccessible areas—fire protection is essential in the context of ISO 22301 (an international standard for Business Continuity Management Systems, or BCMS), with a strong emphasis on continuous prevention. Within the framework of ISO 22301, which addresses business continuity management systems, forest fires and their consequences can be examined through the lens of risk identification and management, continuity planning, and ensuring an adequate response to crises that may jeopardize business operations and community safety.

To implement the standard within fire protection systems, compliance with its requirements must be demonstrated through several key aspects:

(1) Risk Identification and Impact Assessment: According to ISO 22301, the first step in establishing a BCMS is the identification of risks and assessment of their impact on business operations. In this context, global warming and the projected 50% increase in wildfires by 2050 represent a significant threat to human lives, property, the environment, and economic activities. Forest fires can directly disrupt business continuity in fire-prone areas, including agricultural and forested land, and lead to long-term ecological and economic consequences. These projections necessitate intensified safety measures and improved firefighting equipment to prevent and mitigate such events. Every year, thousands of forest fires destroy millions of hectares of land and forest, pollute the air, endanger human lives, animal habitats, and diverse native flora that is essential to certain landscapes—often requiring long-term recovery.

(2) Establishment of Prevention and Response Strategies: ISO 22301 emphasizes a proactive approach to reducing the likelihood of business disruptions. Prevention is the most effective way to reduce the risk of fire outbreaks. Prevention plans within a BCMS should include public education, infrastructure investments in fire protection, equipment maintenance, and the development of strategies to reduce vulnerability in high-risk fire zones. Furthermore, the implementation of effective early warning methods and rapid wildfire response systems can significantly mitigate business impacts. The consequences of forest fires include health issues, the destruction of entire ecosystems, and even parts of cities and settlements. Most forest fires are caused by human activity. Fire protection in hard-to-access areas, particularly in forests and mountainous regions, is a critical issue due to the significant ecological, economic, and social impacts.

(3) Recovery Planning and Business Continuity: Forest fires can cause severe consequences, including ecosystem destruction, air pollution, loss of habitats, and prolonged recovery of affected areas. For organizations operating in vulnerable regions, ISO 22301 requires the development of recovery plans that enable a rapid return to normal operations. This includes plans for the restoration of assets, infrastructure, human resources, and environmental protection. A key element of business continuity management is minimizing recovery time. The high-risk fire season spans from early spring to autumn, but extreme weather caused by global climate change may trigger fires outside this period—even in winter when there is no snow cover. Coastal areas, hinterlands, and especially islands face extremely high fire risks during the summer, particularly in agricultural and forest areas overgrown with dense coniferous forests and scrubland, which are often difficult to access.

(4) Communication and Coordination in Crisis Situations: ISO 22301 also places great importance on effective communication and coordination during

crises. In the context of wildfires, it is essential to establish clear communication channels and coordination mechanisms among relevant entities (government agencies, fire services, local authorities, and other stakeholders) to ensure timely and effective response. In addition, organizations must have aligned internal and external communication plans to inform employees, customers, partners, and the public about the situation's status and the measures being taken.

(5) Continuous Improvement: According to ISO 22301, business continuity management systems must undergo regular review and continuous improvement. Given that fire seasons may become longer and climate change is predictably intensifying, organizations must regularly update their plans in accordance with new risk information, past crisis experiences, and emerging technologies for fire prevention and suppression.

## 2. Characteristics of inaccessible natural areas and the threat of fire

The concept of wildfire hazards in difficult-to-access natural terrains primarily refers to conditions in which a fire may ignite in forest or other wilderness ecosystems covered with flammable vegetation. In the case of the Republic of Croatia, this includes low vegetation such as maquis (scrubland), pastures, and other fire-prone areas. The most significant factors influencing forest fires include meteorological conditions such as air temperature, relative humidity, precipitation, cloud cover, and solar radiation (Barčić, 2020). Soil moisture, particularly the moisture of dead organic matter, also plays a vital role, as it changes in accordance with weather conditions. Additionally, the presence of an ignition source—such as an unextinguished cigarette butt or match—can initiate a fire, while the type of combustible forest material, including tree species and age, biomass quantity, and its chemical and physical properties, determines how the fire will spread (Vajda, 1974). Moreover, both large and small amounts of discarded waste, particularly glass fragments that reflect sunlight, can easily trigger an open flame.

Weather conditions favorable for wildfires include air temperatures above 24°C, relative humidity below 40%, and the absence of precipitation and cloud cover. These conditions account for over 60% of forest fires. As temperatures rise and humidity drops—especially after prolonged dry periods—the risk of fire significantly increases, potentially resulting in large-scale wildfires. The moisture content of forest litter is critical in determining the likelihood of ignition; when litter moisture drops below 12%, approximately 70% of forest fires occur (Klečar, 2009).

The type of vegetation and forest structure also influence the level of fire danger. Dry pine forests and mixed woodlands are particularly vulnerable, while frost, mosses, and lichens may slow fire spread. The energy needed to initiate a fire must exceed the ignition temperature of forest material, which is about 260°C. Additional factors such as accessibility of forest areas, tourist activity, proximity to urban settlements, sanitary conditions of the forest, and the general level of public education on forest safety also affect fire frequency (Klečar, 2009).

A new approach to wildfire protection includes a comprehensive and systematic methodology that integrates all wildfire-related activities, categorized into three key segments: prevention (pre-fire activities), fire suppression management (during-fire actions), and post-fire recovery (after-fire activities). This approach has been recognized as pioneering on the international level, as evidenced by participation in numerous global conferences and forums. A significant value of this new method lies in the development of a regional model for

financially self-sustaining and autonomous vegetation fire prevention (FESB, 2024).

This perspective represents an entirely new way of addressing wildfire protection, paving the way for various new, particularly technical, activities related to forest area protection. Among these innovations are 24-hour video and meteorological surveillance systems with automatic fire detection, and proposals for financially sustainable thinning and clearing of state and private forests. Additionally, it includes the removal of dense scrubland and forest to open access routes to remote areas, utilizing the cleared biomass as fuel in regional energy facilities. This holistic approach integrates preventive measures, effective crisis management during fires, and post-fire recovery, significantly enhancing wildfire safety in the Split-Dalmatia County. As such, it serves as a best-practice example for forest fire management (Knežević, 2017).

In the context of ISO 22301—an international standard for business continuity management—the new approach to wildfire protection can be interpreted through the lens of core normative requirements related to planning, implementation, and maintenance of business continuity systems, with an emphasis on fire protection. This comprehensive approach, encompassing prevention, firefighting, and post-fire recovery, aligns with several key elements of ISO 22301, including:

(1) Risk Management and Business Impact Analysis (BIA): The new wildfire protection system involves identifying, assessing, and managing fire-related risks, meeting the standard's requirements to recognize threats that could compromise business continuity. Activities related to prevention (pre-fire preparedness) and suppression (during-fire response) represent crucial steps in minimizing potential negative impacts on organizations.

(2) Business Continuity Planning (BCP): Managing fire suppression during outbreaks and restoring burned areas afterward are critical components that enable rapid recovery from damage. This reflects ISO 22301's requirements for the development and implementation of effective recovery and restoration plans, allowing organizations to quickly resume normal operations.

(3) Communication and Coordination: The integration of activities at the regional protection level and coordination among various stakeholders (authorities, firefighters, civil protection services) aligns with the need for a coordinated response—essential for effective crisis management. ISO 22301 requires the definition and testing of communication protocols to ensure clear and timely information exchange during emergencies.

(4) Monitoring and Improvement: The elaboration of a financially independent and self-sustaining regional wildfire prevention model reflects a continuous commitment to improving existing protection systems and adapting them to emerging challenges. According to ISO 22301, business continuity management systems must undergo ongoing monitoring, evaluation, and enhancement to maintain long-term effectiveness.

This approach—which integrates all phases from prevention to recovery—offers a holistic fire protection model that is not only pioneering on the national level but also internationally relevant. It supports business continuity during crisis situations in accordance with the requirements of ISO 22301.

## 3. Fire protection methods in inaccessible areas

Forest fires in inaccessible areas represent a major challenge for every country, as they often lead to serious consequences that affect not only forest ecosystems but also the wider environment. In addition to the destruction of forest areas, fires threaten nearby agricultural land and even residential buildings, causing significant damage to local communities. These fires can also

result in long-term ecological consequences, destroying habitats and reducing biodiversity. An additional problem is the fact that large fires often threaten tourist destinations, which is particularly alarming in a country where tourism is a key economic sector. The fear and insecurity caused by such fires can significantly reduce the number of visitors, and thus the income from tourism, thereby destabilizing the entire economic sector. Therefore, the prevention and effective management of forest fires become crucial for preserving not only natural resources but also for the stability and growth of the economy, especially tourism.

Effective fire protection of inaccessible areas represents a challenging aspect of forest and open-space management, especially in regions with a high risk of forest fires. Due to the difficult access to these areas, standard intervention methods are often insufficient, which requires the integration of advanced technological solutions and specialized strategies for fire prevention and suppression (Vajda, 1974). The involvement of local communities and farmers in fire prevention programs also contributes to the effectiveness of protection. Activities such as livestock grazing and maintaining agricultural land reduce the amount of flammable material near forests, thereby reducing the risk of fire outbreaks. In addition, educating the local population about the importance and methods of fire protection increases awareness and cooperation in efforts to preserve inaccessible forest areas (Barčić, 2020). The existence of voluntary fire brigades is also evident in their ability to respond quickly, efficiently, and with dedication to dangers that threaten people and property, as well as their flexibility in adapting to new social changes and trends, providing support and encouraging people to contribute to safety and resilience (Stoprd 2024: 46).

All these measures, when implemented systematically and in coordination with the competent institutions, significantly contribute to reducing the risk of fires in inaccessible areas, thereby preserving natural resources and reducing damage to ecosystems and local communities. In many places, especially in rural and remote areas, professional units are not constantly present and require time to arrive at the scene, while volunteer fire brigades fill that gap by providing assistance that can be crucial in the first moments of a fire, and later as support to professional units and in the recovery after completed operational actions (Stoprd 2024: 46).

Firefighting in inaccessible areas requires specific methods adapted to the challenges posed by difficult terrain and limited access. Among the most effective approaches are aerial interventions, where airplanes and helicopters quickly reach remote locations and release large amounts of water or retardant to suppress the spread of the fire in its early stages. These aerial systems enable continuous supply of firefighting lines with water, especially when land routes are unavailable (Knežević, 2017). Specialized firefighting teams trained to work in harsh conditions use hand tools and portable equipment to create firebreaks and control the fire. Techniques such as controlled burning help to create barriers that prevent the spread of fire. These teams, along with remote extinguishing systems that bring water or foam from natural sources, provide the flexibility and adaptability needed to successfully suppress fires in inaccessible areas (Klečar, 2009).

The use of drones with thermal cameras allows for precise monitoring of fire spread and identification of high-temperature hotspots, facilitating strategic decision-making. The integration of local communities into fire protection activities, through training and equipping volunteer units, further enhances the effectiveness of interventions. This collaboration enables a quick response and local knowledge that can be crucial in the early stages of a fire, providing key support to professional teams (Barčić, 2020).

With climate change, the fire season is becoming longer and more extreme, and new challenges are emerging, such as floods, earthquakes, industrial accidents, landslides, and strong wind gusts. Volunteer fire brigades are increasingly being trained not only for firefighting but also for a wide range of emergency interventions, often even as primary responders without the support of professional units (Stoprd 2024: 47).

Nevertheless, the most effective fire protection in inaccessible areas is well-implemented prevention and monitoring, which prevents the emergence of forest and other open-space fires, thereby reducing the need for extensive intervention and major damage to nature.

## 4. Preventive fire protection measures in inaccessible areas

According to ISO 22301, which relates to business continuity management, preventive fire protection measures in inaccessible areas can be integrated into a broader framework of risk management and business continuity. Although ISO 22301 does not specifically address fire protection in inaccessible areas, it provides guidelines for planning, risk assessment, and the development and implementation of preventive measures, including fire protection. In the context of inaccessible areas, preventive measures may include the following:

- Risk assessment and business continuity impact analysis
- Preventive actions to reduce the risk of fire outbreaks
- Training and crisis simulations
- Technological solutions and communication systems
- Green belts and forest fire prevention zones
- Collaboration with local communities and stakeholders
- Inclusion of environmental aspects in preventive measures
- Preparation and regular updating of protection plans
- Maintenance of equipment and infrastructure

Although the Foundling Hospital, established in 1741, is often cited as the first nonprofit organization, the first known nonprofit organization in the world is likely the Union Fire Company, founded in the U.S. in 1736. In today's context, firefighting units are generally organized as volunteer-based entities, commonly known as "volunteer fire departments," and this concept can be closely linked to the first firefighting company, making it arguably the earliest known nonprofit organization (Stoprd 2024: 16).

Volunteer fire departments, as key actors in launching preventive activities, bear primary responsibility for their implementation in accordance with their statutes. Their particular advantage in this context lies in the fact that members are deeply familiar with the terrain, including inaccessible, remote, and rarely visited areas such as mountains, valleys, and dense forests. This local knowledge makes them extremely valuable in fire prevention, especially in areas that are difficult to access and require a specific approach to preventive and intervention activities.

Thinning and clearing forest areas includes the removal of dry trees, branches, shrubs, and low vegetation, which reduces the amount of flammable material on the forest floor. This process also improves forest accessibility, especially in hard-to-reach areas. By reducing accumulated material, the likelihood of forest fires is lowered, and faster and more efficient responses from firefighting teams are enabled. The woody biomass collected in this process can serve as an additional source of income by being used in small local energy plants to generate heat, electricity, and cooling, thereby creating added economic value.

Clearing corridors and access roads to inaccessible forest areas, including both

public and private properties, allows for easy and quick access for firefighting vehicles and equipment. In addition to enhancing safety in the event of a fire, putting these roads to use for hiking, sports, recreation, health tourism, and rural tourism brings added benefits to local communities. The wood material obtained during the creation and maintenance of these roads can also be used as biomass fuel, optimizing resource utilization (Klečar, 2009).

Planning and managing vegetation cover to create natural barriers against fire spread is another important protection measure. By applying certain plant species that slow down or halt fire spread, the intensity of fires in specific areas can be significantly reduced. These natural barriers contribute to ecosystem conservation and minimize fire-related damages (Klečar, 2009). Diversifying land use—including livestock farming, agriculture, and the development of rural, recreational, sports, and health tourism—supports the sustainable development of rural areas. This variety of activities reduces the concentration of combustible material in certain areas and promotes the responsible use of natural resources (FESB, 2024).

Equipping larger agricultural areas with systems for rainwater collection during winter and installing large water tanks on elevated ground is crucial for effective firefighting, not only in those areas but also in surrounding wilderness, abandoned pastures, and agricultural land that is less accessible. These tanks can also be used for drip irrigation, livestock watering, and rural tourism, offering multiple benefits to local communities and contributing to resilience against droughts and fires (Vajda, 1974).

In areas where it is feasible—particularly on key observation points, lookouts, and other elevations offering views of inaccessible terrain—it is necessary to install 24-hour surveillance systems, including both visible-spectrum and infrared cameras. These systems allow for automatic detection of smoke and fire, with real-time and archived data accessible via the internet. Such surveillance ensures a virtual presence at fire-prone sites, significantly improving response speed and coordination during a fire event.

The calculation of a micro-location fire risk index is based on meteorological data and vegetation characteristics. This dynamic index uses data from a network of mini meteorological stations distributed throughout the region, transmitting key real-time data such as wind speed and direction, temperature, humidity, pressure, and solar radiation. This network not only enhances fire risk management but also aids farmers in pest control and provides tourists with valuable outdoor activity planning information.

The use of vegetation fire spread simulators is another highly valuable tool in the prevention phase, enabling training and preparation for various fire scenarios in different county regions and under varying meteorological conditions. After a fire outbreak, the simulator is also used to predict potential directions of the fire front, improving the effectiveness of interventions and minimizing damage (FESB, 2024).

Consistent application of these measures would significantly reduce the risk of forest fires, while also bringing benefits to the economy, tourism, and agriculture—making this approach both comprehensive and integrated. In addition to lowering fire danger, these systems support the development of local communities through various economically sustainable activities and the responsible management of natural resources. For example, using collected biomass in local energy plants contributes to energy independence and the reduction of greenhouse gas emissions.

An example of a quality implementation of such a system is visible in the Split-Dalmatia County, one of the counties with the greatest fire threats in inaccessible terrain, ranging from islands and the coastline to the mountainous inland areas of the Dalmatian

highlands, Dinara, and the Dalmatian Hinterland. The system applied in Split-Dalmatia County has proven relatively effective in fire detection and timely and efficient prevention. However, it has also become evident that significantly more investment is needed in technological solutions, such as simulators and video surveillance systems (FESB, 2024).

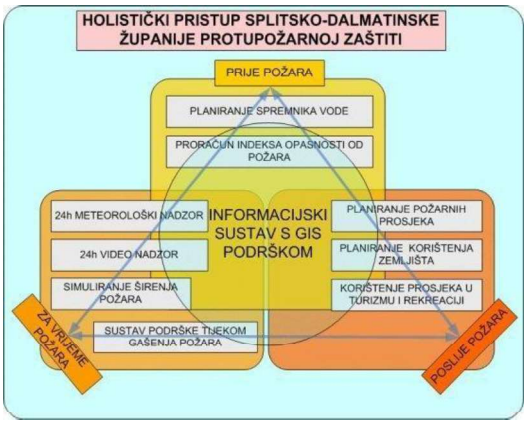


**Figure 1.** Diagram of the Holistic Approach to Fire Protection in the Split-Dalmatia County (FESB, 2024)

Effective protection of open areas from fire includes, among other things, a well-organized observation and reporting service, whose main task is the early detection of developing fires from observation points. According to the Regulation on Forest Fire Protection (Official Gazette No. 26, February 20, 2003), this service must operate continuously, especially during periods of high and very high fire risk, for forests classified under the first degree of fire hazard. The establishment of this service is the responsibility of legal entities managing the forests, as well as local governments for forest areas owned by private individuals.

The integrated fire monitoring system project proposes an advanced monitoring system that would cover all areas with increased fire risk. This system would significantly supplement the existing observation and reporting services, which rely on human observers, by enabling faster and more precise fire detection and more efficient response.

The implementation of measures, which are essential and practiced in many parts of the world, can also have very positive implications for tourism and agriculture. Safer and better-maintained forest areas become more attractive to tourists, encouraging the development of ecotourism and outdoor activities. Farmers benefit from weather and climate monitoring systems, allowing for better planning and crop protection. This creates a synergy between different sectors, where fire protection measures simultaneously promote economic development and environmental conservation.

On the other hand, some measures can be implemented quickly, such as 24-hour video and meteorological surveillance with automatic vegetation fire detection. This system enables continuous monitoring of potentially endangered areas and quick response in case of smoke or fire detection. Rapid detection and intervention are crucial for preventing the spread of fires and minimizing damage. In addition, the collected data can be used for analysis and prediction of future risks, contributing to long-term planning and forest resource management. The combination of all the above-mentioned preventive measures is aimed at reducing the risk of fire outbreaks, minimizing potential damage, and ensuring rapid recovery in the event of a fire, thereby contributing to business continuity in accordance with the ISO 22301 standard.

## 5. Conclusion

In conclusion, fire protection in inaccessible areas, particularly in coastal and mountainous regions, requires a comprehensive approach that includes prevention, firefighting, and the rehabilitation of burned areas, with a significant focus on improving technologies and cooperation among local communities.

Given the specific challenges, such as difficult accessibility and specific meteorological conditions, the approach must be designed to incorporate preventive measures such as forest thinning and the creation of protective lines, as well as systems for video and meteorological monitoring that enable faster response. Such an approach not only reduces the risk of fires but also contributes to the sustainability of forest resources, through the effective use of biomass for energy needs and the reduction of greenhouse gas emissions. The inclusion of innovative technologies, such as rainwater collection systems, and the development of a network of mini meteorological stations and fire spread simulators, are key to improving coordination, training, and the ability to effectively manage fire risks. This integrated approach not only reduces fire threats but also contributes to the economic development of local communities through resource optimization and infrastructure improvement, which is in line with the principles of the ISO 22301 standard on business continuity management and the protection of critical infrastructure.

## References:


Barčić, D. (2020). Klasifikacija i ponašanje šumskih požara u protupožarnoj zaštiti. *Vatrogastvo i upravljanje požarima*, 25-45.

FESB. (2024). *Integralna protupožarna zaštita*. Eksperimentalni Web portal protupožarne zaštite Splitsko - dalmatinske županije. Retrieved from http://vatra.fesb.hr/index.php?option=com_content&view=article&id=47&Itemid=57

ISO 22301 https://repozitorij.hzn.hr/norm/HRN+EN+ISO+22301%3A2019

Klečar, S. (2009). *Osnove gašenja požara raslinja.* Zagreb: MI Star. ISBN 978-953-96741-2-8

Knežević, D. (2017). Retardanti protiv požara raslinja. *Vatrogastvo i upravljanje požarima*, 21-28.

Stoprd, M. (2024). *Svrha dobrovoljnih vatrogasnih društava*, Zagreb: Vatrogasni vjesnik, Hrvatska vatrogasna zajednica, 2024/11/12, 46-47.

Stoprd, M. (2024.) *Povijest neprofitnih organizacija*, Zagreb: Udruga.hr, 2024/83, 16-17.s

Vajda, Z. (1974). *Nauka o zaštiti šuma.* Zagreb: Školska knjiga. 1-482.



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