Chapter 5
Dynamic Spatial-Distributed Fire Risk Analysis

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ABSTRACT

The chapter develops a dynamic spatial-distributed model of forest fire risk. The structure of forest fire risk is represented by two interrelated groups of components describing a potential of forest fire and describing valuable objects being under fire influence. The concept of fire risk which contains the probability of forest fire occurrence, its intensity, and effect, is extended using the threat as the additional prognostic spatial-temporal component that has a predictive property and allows forecasting the possibility of losses at any time. The model of fire risk is based on three stages: potential risk, the source of which is described by fire danger; risk of threat of active forest fire which hasn't covered valuable object yet; risk of destruction when the active fire has covered valuable object. Representation of risk as a process based on three stages allows describing the dynamics of risk in real-time systems, getting insight into risk nature, as well as diagnosing the situation in real time.

BACKGROUND

The first decade of the XXI century is characterized by activation of forest fires that cause damages, injuries, and even deaths. Expanding the scope of forest fires occurs due to such factors as increasing the population, urbanization, environmental degradation, global warming, etc. Thus, at present, the problem of timely and grounded decision making in real-time forest fire response, which allows mitigating fire damage, is in the focus of attention of researchers (Sherstjuk, V., Zharikova, M. & Sokol, I., 2018).

Decision making in a forest fire response is directly related to forest fire risk assessment. So, there is a growing interest in developing risk-oriented decision support systems for real-time forest fire response. Fire risk is a potential for a valuable object to take losses as a result of a forest fire.

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Taking into account the fact that risk is a basis for decision making for fire response, it’s interesting to consider a place of risk assessment in a full fire management cycle (Fig. 1) (Kappes, 2011). This cycle contains three main phases:

1. Fire prevention;
2. Fire response;
3. Regeneration after a fire.

Currently, risk assessment is understood as a static value describing a potential effect from the impact of fire on the valuable objects. Accordingly, risk assessing is performed only in the frame of the first phase of the fire management cycle (Fig. 1). Whereas in real-time systems, end-to-end assessment of fire risk not only in the prevention phase but also in the respond and regeneration phases is of great interest.

There is a vast literature on forest fire risk assessment. The majority of the authors propose to assess risk quantitatively, using probabilistic methods of simulation modeling not suitable for the assessment of fire risk in real time, where probability is out of the question (Zharikova, M., 2018). Such methods of risk assessment lead to a high computational complexity and reduce a performance of a decision support system significantly, which is not allowed in the real-time systems. To increase the representativeness of statistical samples the big areas and the big time intervals are taken into account. On top of it, in existing works, no attention is paid to the assessment of fire risk dynamics in real time. Instead of this, a static assessment of risk components is considered.


Although the terminology related to fire risk has experienced a long term evolution and has its traditions, it is still controversial.

There is no unique definition of the term “risk” and the notions coming from it such as “danger”, “threat”, etc. Many researchers focus on the losses describing risk as to the interrelation between the physical probability of fire occurrence and potential losses for people and the environment (Mimbrero, M.,