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RESEARCH ARTICLE

YUE Jinzhu, FENG Zhongke, JIANG Wei, YANG Xiaoqin

Risk management: A probe and study on forest fires

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Abstract The subject of risk management is attracting more and more attention around the world. The risk of forest fire disasters should be faced and dealt with for forest fires cannot be avoided. Treating forest fire disasters as a risk management issue promotes important measures and methods for fire fighters to prevent, reduce and control the risks of forest fires. In this paper, the risk concept and risk connotation as well as the management risks for forest fire suppression are discussed clearly. Issues such as risk judgments, risk analysis, risk control and the assessment of risk, including their contents and corresponding methods are clarified.

Keywords risk management, risk recognition, risk analysis, risk evaluation, risk control, forest fire disaster

1 Introduction

The forest is one of the most important natural resources and fundamental things needed for human survival and social development. Forest fires, however, occur occasionally because of the uncontrolled actions of human beings or, sometimes, unusual natural factors. Statistical data have shown that about 220,000 forest fires occur each year around the world. The area covered by forest fires is more than 6.4 million hectares, representing 0.18% of the total area of forests on the planet (Wang, 2002). Moreover, since the 1970s, the frequency of forest fires and the losses they have caused is increasing, while the world climate has been getting warmer. It is difficult to assess the losses caused by fire. More than 700,000 forest fires have occurred in China since 1950. The affected forest area totals 39 million hectares, with over 33 thousand people injured or killed by these fires. China has suffered direct economic loss of hundreds of billions of RMB (Liu, 2005). Forest fires have not only reduced biodiversity and destroyed forest resources directly, but have also polluted the atmosphere by emitting a great deal of smoke and dust. Therefore, forest fires have also diminished the quality of people's lives, thus doing a great deal of harm to social stability and development.

Forestation is the main constituent part of the terrestrial ecosystem. Forest fire, as the one of the most dangerous factors of the forest, may be out of control. The reason for fire ignition may be due to factors related to nature, society, the economy and so on. Fire precaution and extinguishment is important for disaster prevention, reduction and control. Because of the high-frequency, complexity, high-risk and uncertainty of forest fires (Teie, 1994), there must be some risks in fire prevention or extinguishment. For this reason, the risk management of forest fires is a difficult problem which cannot be avoided. The biggest part of research related to fire risk management is focused on urban fire protection (Zheng, 2003), and not so much on forest fire protection. The afforestation proportion increases annually with the advance of six major projects in China forestry. The number of drought days also increases as the global temperature rises. With these factors increasing, the number of fires in our country is on an upward trend. Therefore, it is realistic and important to bring forest fire risks into the realm of risk management, and to pay more attention to the risk of forest fires.

2 Risk and risk management

The concept of risk originally appeared in western economic studies in the late nineteenth century. At that time, it was applied in many disciplines such as architecture, engineering, sociology and finance (Union Strength Consultant of Enterprise Management Company, 2005). Each person has his own perception of the connotation of risk due to their unique research perspectives and experiences. There is not one unified definition for disaster risk in academia so far.

In 1981, shortly after the founding of the American Risk and Insurance Association, a special committee was set to

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YUE Jinzhu (✉), FENG Zhongke, JIANG Wei
College of Natural Resources and Environment, Beijing Forestry University, Beijing 100083, China
E-mail: yuephd@sina.com

YANG Xiaoqin
Qiaotou State Forest Farm of the Wengniute Banner, Inner Mongolia, Chifeng 024000, China

give a definition. They proposed 14 different definitions about what risk constituted. In 1997, the International Union of Geological Sciences defined risk as the possibility of an adverse event occurring and its possible severe consequences to health, property or environment. The UN gave an expression for the risk of natural disaster as Risk = Hazard × Vulnerability.

Generally speaking, three related factors constitute risk, these being an adverse event, the possibility of it occurring and its consequences.

Risk management is to process the risk using systematic and standard methods. Generally there are four stages in risk management: judgment, analysis, assessment and control of the risk. During all of these four stages, judgment and analysis are the preconditions of assessment, and assessments are the basis of the control.

Integrated analysis of risk has prevailed over the field of natural disaster management in recent years, and it has been a trend to manage the risk and deal with the emergency with integrated analysis methods.

Many fields have been explored by risk-studying scholars in many countries, including insurance, bank, investment, and flooding. They usually lay emphasis on how to process the four previously-mentioned aspects to get the best results for lowering and controlling risks. Some achievements have already been made.

The generally-used risk management concept set up by the standards association of Australia and New Zealand (Zhang, 2003) is illustrated in Fig. 1. The International Institute of Risk Management in Switzerland has been dedicating time to this field, and the systematic risk management medal (Zhang, 2003) was awarded as shown in Fig. 2. Okada Norio, a professor at the Disaster Prevention Research Institute of Kyoto University, proposed a risk-discerning pattern which used PDCA (P for plan, D for do, C for check, A for action) to describe the actual procedure of risk management. Recently, a five-year-long project called "empirical research of ready-for-disasters society" is being developed with the Japanese National Institute of Disaster Reduction (Chen, 2004) taking the lead role.

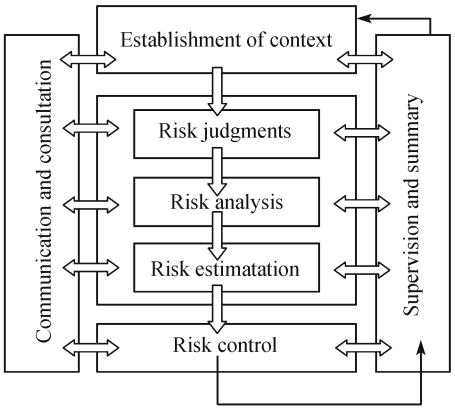

Fig. 1 The framework of disaster risk management (AS/NZS4360:1999)

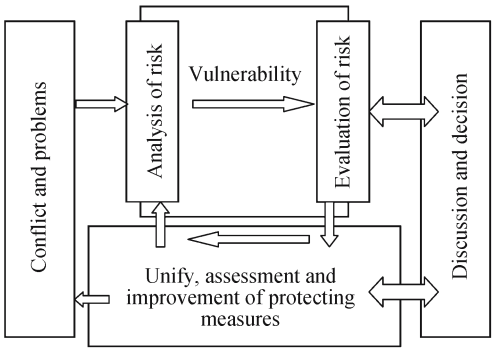

Fig. 2 The system approach of disaster risk management (Stephan Bieri 2000)

3 Forest fire risk and risk management

The International Risk Management Council convened in September 2005, in Beijing. It conveyed such information that risk management is becoming a scientific domain to which the global society should pay more attention. The United Nations proposed that analysis of the disaster question should integrate the risk management concept. The international society proposed urgent globalization of risk management, and, additionally, will study the risk management question from the overall point of view of producing a batch of advancing and foresighted research results.

Regarding the fire risk and the risk management question, many domestic and foreign experts have done some research, but at present the domestic issues are mainly concentrated on city fire risk, and so there is not enough research and analysis of forest fire disasters and their associated risk management. Forest fires not only cause the loss of forest resources, losses to the ecological environment and risks of the life and property of the people living in the forest region but also cause the forest fire fighter to face personal safety risk. Reference to the international convention and the general procedure, the forest fire disaster should be brought in the risk management, and the risk management idea should be introduced into the forest fire disaster research area, making the study of forest fire management an important branch of risk management.

To develop forest fire research under the banner of risk management, we need to know the concept and the connotation of forest fire risk and risk management first. The concept of forest fire risk is related to the possibility of damage to people's health and property, environment and its possible severe consequences. As previously mentioned, forest fire risk management means to manage forest fire risk using systematic and regulating methods through the four-step procedure (that is to say, risk judgment, analysis, assessment and control), thereby lowering the possibility of risk and, subsequently, to minimize any losses. From the viewpoint of the systematic theory, forest fire risk management is a multi-lateral project. People, material, time,

environment and information all are parts of it. As the integrity of judging and analyzing, measuring and forecasting, controlling and handling, this project must be built around methods generally used in systematic projections.

3.1 Risk judgment

Risk judgment is the beginning and the basis of the whole risk management concept. What we shall do is to find and discern all kinds of influencing factors that are related to forest fire risk, and then determine the key factors from experience. Thus we can forecast the possibility of forest fires by the changing environmental factors in a period of time or in certain areas. Discerning risk is a complex domain because it requires statistical data, experience, comprehensive analysis and scientific catalogue.

Figure 3 shows how forest fire occurs, spreads and is extinguished. Research and experience tell us that most forest fires are caused by humans, while few are caused by natural factors. Every forest fire requires the following three necessary preconditions: combustible materials, high temperature and oxygen. This means environmental factors greatly influence forest fire, for example climate, terrain, plants, and the economic situation (Wang and Yue, 2005). From deeper research on the factors related to fire ignition and spread, the key factors have been defined as combustible materials, climate, terrain and fire source.

3.2 Forest fire risk analysis

Forest fire risk analysis provides a basis for risk assessment and forecast related to the scientific analysis and precision of the following factors: probability, time, area, procedure and the consequences of the forest fire. Prior to the analysis, the historical fire data, the loss caused by fire, the strength of the fire fighting resources, terrain, weather, social and economic conditions, etc. must be known. In order to analyze the forest fire risk, we should set a goal for the risk management and determine the tolerance level. The tolerance level is a very important factor with which to assess forest fire risk. It varies in different countries and regions depending on social and economic development levels. Commonly, the higher the economic level, the lower the tolerance level is. There are several means to analyze fire risk, which can be divided into three categories: qualitative analysis, quantitative analysis and qualitative-quantitative analysis. Generally speaking, qualitative analysis is used to determine interrelated factors, quantitative analysis to determine the ruling factors, and qualitative-quantitative analysis to analyze risk and to divide the areas at different fire risk level.

3.3 Forest fire risk assessment

Assessment and prediction form the most important basis for risk copying and control. Assessment is the process to determine the risk level and ascertain if it is under the tolerance and base level, thus enabling tactics to be adopted that reduce the risk level. To do this efficiently, realistic theory and useful methods should be adopted. The theoretical assessment combined with the experience of the assessor could help to make a more suitable plan to predict and to handle the emergency. The generally recognized assessment methods include but are not limited to event tree analysis (ETA), fault tree analysis (FTA), analytical hierarchy process (AHP), environment analysis system (EAS), human reliability analysis (HRA), preliminary hazard analysis (PHA), hazard and operability studies (HAZOPS) (Cheng et al., 2004). Taking account of the mystical properties of forest fire risk, a model set up using uncertain mathematical basis or vague integration is required.

After completing the detailed analysis outlined above, an indices system can be developed to assess the forest fire risk. The factors which are combined in the indices system include: climate, terrain, plants, fire-control, socio-economical and historical data.

This system is illustrated as the Fig. 4.

Thus, the coefficient of forest fire risk can be expressed as

$$R = f(C, T, P, F, S, H)$$

where R is the coefficient, C is the influencing factor of climate, T is terrain, P is plants, F is the situation of fire-fighting, S is the economic situation, and H is the historical influence.

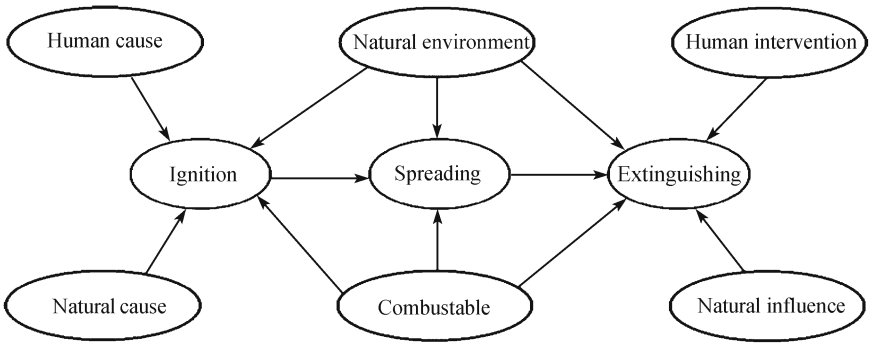

Fig. 3 Graph on the state of forest fire

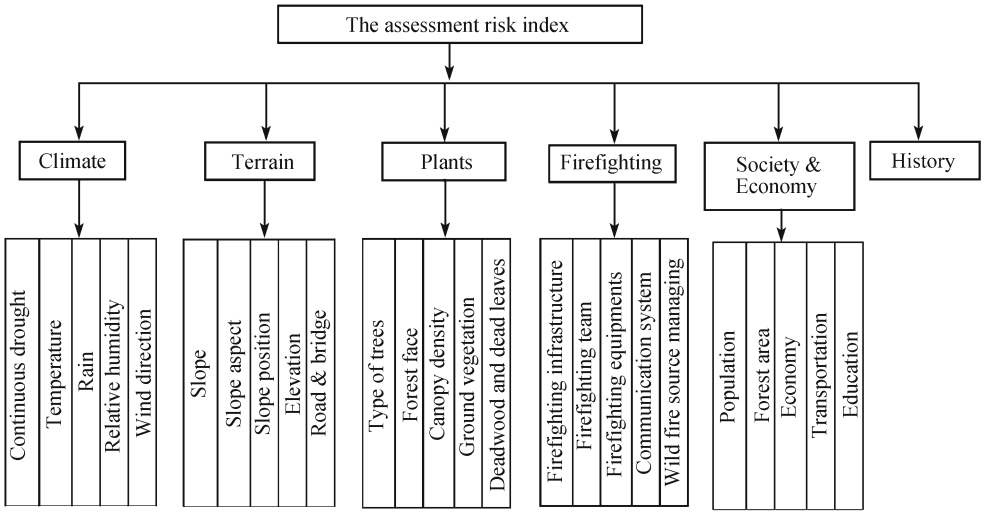

Fig. 4 The estimating structure of forest fire disaster risk

In practice, it is difficult to make an ideal model due to the complexity of the fire spread and uncertainty of forest fires. We set up the model with two factors to make the fire assessment more realistic. The two factors are the probability of ignition and the consequence of the fire. Thus, the coefficient of the fire risk can be expressed in the formula: $R = f(p, c)$. where p is the possibility of danger, and can be substituted with the fire ignition frequency; c is the possible severe consequences, including the loss of forest resources, humans and other direct or indirect loss. For the formula to be applicable, R may be the multiple of p and c, thus the parameter would be quantitative (Huang, 1999).

There are two methods: one is to quantify the parameters by analyzing the historical fire data from the statistical data; the other is by obtaining the value from an estimating model based on uncertain integration or vague matrices. The final value is the basis for the forest fire risk assessment.

3.4 Risk control

Risk control and handling is the ultimate objective of risk management. It is the action or theory to reduce or to control the risk of fire based on the result of the fire risk assessment. The measures can generally be put into three categories: technological measures, cultural measures, policies and regulations (including many concrete measures, such as technology developing, preventive-file establishing, risk forecasting, risk controlling, risk transferring etc.). All of these factors form the emergency-dealing mechanism (Yue and Feng, 2006), with which to fore-warn, to prepare for danger, reduce disaster and to provide disaster relief. In practice, we persist with the principle of people-oriented, safety first planning, to provide important precautions, to make prevention a priority, to eliminate the risk positively, enhance technical handling, and to provide comprehensive programs for fire control. We must pay more attention to the utilization of the means, such as risk detection, risk prediction, risk avoidance, risk transfer, risk control and the emergency handling and decision technology.

The ultimate goal is to gain the largest benefits possible and to suffer the least loss. The idea and the technology should be tailored to the need of our country's risk control, and to follow the trend set by the development of other countries (Shi et al., 2005).

4 Conclusions and discussion

This article has discussed the connotation of forest fire risk, forest fire and risk management within the realm of risk management, and elaborated on the content and method of risk judgment, analysis of risk, assessment of risk and risk control briefly. These principles are important in practice when improving fire management, controlling forest fires and protecting the national forest resources effectively. However, the risk-assessment model outlined in this article still remains at the rudimentary phase. More research of the vague integration model and its practical application should be carried out to perfect the management system.

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