Comprehensive Comparative Study of Forest Fire Emergency Management between China and the United States

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Abstract. Forest ecological firefighting engineering is crucial for maintaining the functionality of the terrestrial ecosystem, albeit a complex and challenging task. The forest ecosystem constitute an integral component of the Earth's ecological environment system, playing an indispensable role in ensuring China's forest terrestrial ecosystem's structure and preserving its natural biodiversity. This paper conducts a comprehensive comparative study of forest fire emergency management both domestically and internationally. It introduces the current situation and characteristics of forest fires and analyzes their impacts on the environment, economy, and society. Using the domestic " Liangshan County Fire " and the American "California Forest Fire" as case studies, it explores the organizational mechanisms, technical means, and response measures of forest fire emergency management. The paper summarizes the advantages and disadvantages of forest fire emergency management at home and abroad and proposes suggestions for improvement. China should strengthen cooperation with the international community, learn from foreign experiences and technical means, while also enhancing supervision and management to prevent fires. This paper aims to provide reference and guidance for China's forest fire emergency management.

Keywords: emergency management , forest fire , firefighting and rescue

1 Introduction

Forests are crucial for development, but forest fires pose ongoing risks, exacerbated by factors like climate change [1]. In California, USA, where almost half the forests are untouched, putting out fires is challenging due to limited technology. The Incident Command System (ICS) [2], a global emergency model, faces tests from recent wildfires, prompting updates. Liangshan County's rugged terrain and dense forests heighten fire risks, often compounded by phenomena like fire tornadoes. Suppressing fires can trigger further disasters, complicating rescue efforts. Analyzing responses in

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Liangshan County [3] and California [4] offers insights to enhance post-fire strategies, improving emergency management and protecting lives and resources.

2 Overview of forest fires and emergency response

Forest fires, defined as uncontrolled fires that spread within forest areas, pose significant threats to ecosystems and human lives. In California, abundant forest resources, coupled with flammable chaparral leaves, contribute to frequent wildfires, particularly during the summer months. Over the years, California has witnessed numerous large-scale wildfires, collectively affecting 4% of the state's land area [5].

Liangshan County, situated in western Sichuan Province, features rugged terrain and a high forest coverage of 61.9%. Harsh climatic conditions, diverse vegetation, and human activities have made it prone to severe forest fires. Since the establishment of the People's Republic of China, Liangshan has experienced over 5,000 fires, resulting in the destruction of over 4.5 million mu of forest area. Consequently, it has been designated as a first-level fire-prone area by the Sichuan Provincial Forest Fire Command. Figure 1 illustrates the emergency response flowchart for forest fires in China.

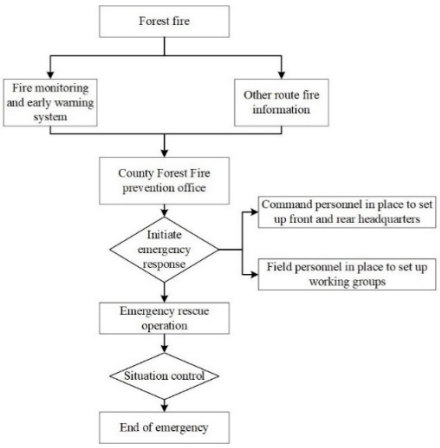

Fig. 1. Flow Chart of Forest Fire Emergency Response.

3 Fire case studies

3.1 Overview of forest fire case in xichang city, liangshan prefecture

Liangshan Prefecture is located in the southwest of Sichuan Province, at the northeast end of the Hengduan Mountains, situated between the Sichuan Basin and the Yunnan Plateau. Spanning an area of 60,423 square kilometers, it had a population of 531,300 as of the end of 2019. The region's terrain varies significantly, with elevated northwest areas and relatively low southeast areas. Liangshan Prefecture experiences a subtropical monsoon climate, with a dry season from November to April, character-

ized by low rainfall and abundant sunshine, and a rainy season from May to October, marked by high humidity and heavy rainfall.

On March 30, 2020, at 15:00, a forest fire broke out in Xichang City, Liangshan County, Sichuan Province, China. The timing of the fire coincided with the dry season in Liangshan Prefecture, characterized by arid environmental conditions, indicating an elevated risk of fire occurrence. The sequence of events of the fire incident is illustrated in Figure 2.

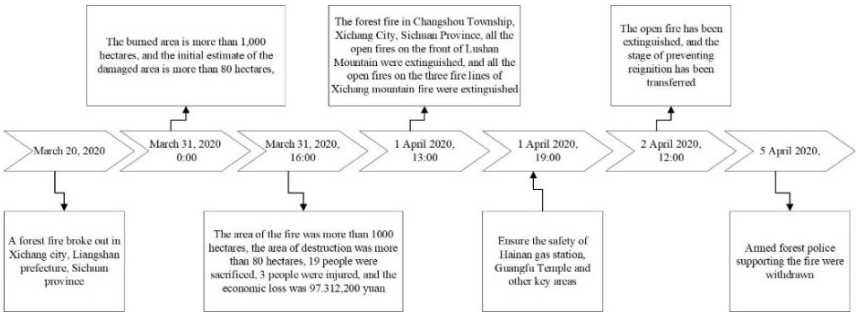

Fig. 2. Flow Chart of Fire Occurrence Time.

Emergency Response Process

(1) On-site Rescue: On-site rescue operations were conducted from March 30, 2020, to April 2, 2020. The situation of on-site rescue is depicted in Figure 3.

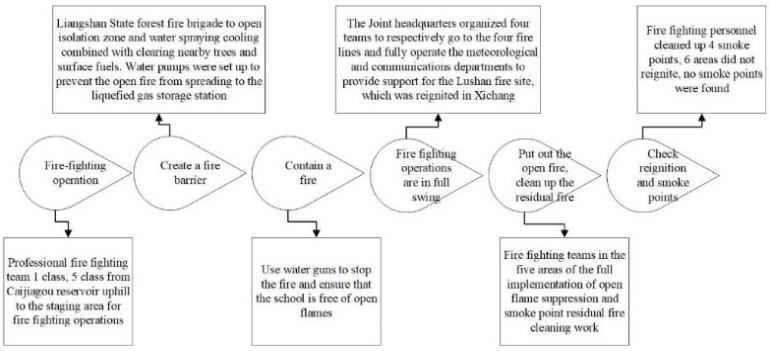

Fig. 3. Rescue Flow Chart.

(2) Rescue Forces: Following the fire incident, the Emergency Management Bureau swiftly dispatched six firefighting and rescue brigades comprising 430 officers, three sets of remote water supply firefighting systems, 63 large water tanks and foam fire trucks, hand-carrying, hand-pushing, and water-drawing mobile pumps, firefighting hoses, and other emergency materials and equipment were mobilized for reinforcement. In accordance with unified reinforcement orders issued by the Emer-gency Management Department, 1,100 officers from the Sichuan Forest Fire Brigade and the Firefighting and Rescue Brigade actively engaged in firefighting operations on the

front lines. Moreover, four rescue helicopters were initially deployed to participate in forest fire emergency rescue operations, and subsequently, three helicopters from Hunan, Zhejiang, and Shandong were dispatched to join disaster relief and fire-fighting efforts.

(3) Transportation, Evacuation, and Power Restoration Status: refer to Table 1.

Table 1. Traffic, Evacuation and Power Recovery.

Traffic condition	Evacuation condition	Power restoration
On the afternoon of March 30, 2020, the Xichang Public Security Bureau issued a notice to conduct emergency traffic control on some sections of the road.	As of March 31, 2020, the South Campus has completed the evacuation of 29 students and more than 500 faculty and staff members and their families.	At 20:25 on March 30, 2020, the local power department has sent emergency vehicles and more than 300 people to the scene, and the power outage area is being restored in an orderly manner.

(4) Situation Control and Post-Emergency Rescue Work: Subsequent to the forest fire incident, the Secretary of the Sichuan Provincial Party Committee emphasized the urgent need to extinguish the large-scale forest fire in the shortest possible time, ensuring the safety of local residents and rescue personnel. Post-emergency disposal work commenced, including convening a press conference to report on relevant rescue efforts, initiating the process of declaring martyrs and paying tribute to firefighters who sacrificed their lives during the forest fire in Xichang, facilitating social assistance channels, and conducting an accident investigation and accountability process.

3.2 Overview of the california forest fire case in the united states

On November 8, 2018, a forest fire erupted in Paradise, Butte County, Northern California, prompting a state of emergency declaration by the Butte County Sheriff's Office [8][9]. The Los Angeles County Fire Department initiated urgent evacuation measures and dispatched professional firefighters for rescue operations. The situation of on-site rescue is depicted in Figure 4.

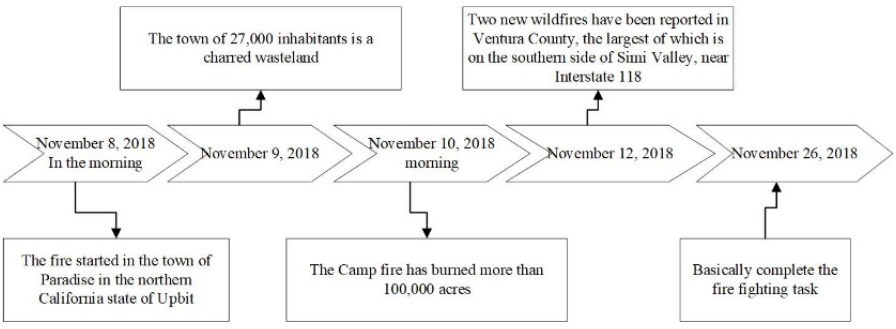

Fig. 4. Flow Chart of Fire Occurrence Time.

Emergency Response Process

(1)On-site Rescue: Operations were conducted from November 9 to November 26, 2018. The situation of on-site rescue is depicted in Figure 5.

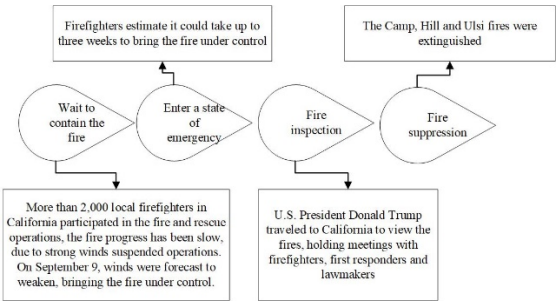

Fig. 5. Rescue Flow Chart

(2) Rescue Forces: CAL FIRE and the Fire Department mobilized 8,400 firefighters, 980 fire engines, 40 helicopters, and specialized aircraft. The California National Guard deployed 930 military personnel, 13 specialized aircraft, and support from other states.

(3) Transportation, Evacuation, and Power Restoration: See Table 2.

Table 2. Traffic, Evacuation and Power Recovery.

Traffic condition	Evacuation condition	Power restoration
The California Highway Patrol participated in the construction and maintenance of rapid emergency lanes, strengthened road patrols, helped clear roads, and ensured the rapid passage of emergency supplies.	In November 2018, about 3,000 people in the town of Paradise in Butte County were ordered to evacuate, and 293 people went missing during the evacuation.	Power was shut down in parts of the county to prevent the fire from spreading and causing other fires.

(4) Situation Control and Post-Emergency Relief: President Trump and FEMA discussed reconstruction, while CAL FIRE initiated an investigation into PG&E. Post-disaster relief efforts began, including press conferences on ongoing operations.

4 Case analysis

4.1 Activation of emergency mechanisms, establishment of emergency organizations: Comparison and analysis

In China, a comprehensive emergency relief plan for forest fire management, along with systems for disaster information transmission and wildfire risk assessment, are in place. The emergency management system is led by local governments, with technical support from relevant departments under the State Council, notably the State Coun-

cil's Emergency Management Office. In January 2023, the China Fire and Rescue Bureau merged with the Forest Fire Bureau to form the National Fire and Rescue Bureau, creating a unified national firefighting and rescue team.

In the United States, emergency management operates at federal, state, and local levels, with FEMA and DHS being the main agencies. Operational mechanisms include emergency operation centers at various levels. The legal framework ensures effective emergency response, with clear responsibilities for firefighting agencies at federal and state levels [6]. However, coordination between central and local governments can be challenging, leading to delays in disaster response.

The forest fire emergency response in China is primarily led by local governments, with technical support from relevant State Council departments, ensuring swift action. However, there is room for improvement in tracking and coordinating the entire process, leading to inefficiencies and challenges in summarizing rescue efforts[7]. Investigations in Liangshan Prefecture revealed gaps in deployment and implementation of emergency plans, highlighting the need for enhancements in forest fire emergency plans and operational procedures.

4.2 Emergency rescue comparison and analysis

In the United States, rescue teams combine professional and volunteer approaches at federal, state, county, and municipal levels. FEMA implements a four-level assessment and training system for its Incident Management Team, ensuring competence before joining rescue operations. California's government plays a key role in firefighting efforts, with the state's capabilities improving over time. Most firefighters and equipment come from California, demonstrating the state's firefighting capacity.

In China, Forest Fire Rescue Teams and National Comprehensive Fire Rescue Teams are the primary responders to forest fires. Nearby teams join firefighting operations under unified commands from the Forest Fire Bureau and Emergency Management Department. China's response to forest fires tends to be quicker and more coordinated due to a unified command system. Routine training includes joint forest fire drills, enhancing cooperation and response capabilities.

The rescue philosophies of China and the United States differ. China prioritizes saving lives, while the United States sometimes delays firefighting efforts due to procedural complexities. Despite this, local fire and police departments in the US establish command centers for efficient coordination during small-scale fires.

In terms of transportation, China implements traffic control for smooth evacuation, while the US sets up emergency channels to supply materials. However, in power restoration, China ensures timely restoration, while the US evacuation plans may lack security measures and coordination, as seen in the California wildfires.

4.3 Post-emergency management comparison and analysis

After the California forest fires, many residents were displaced, leading to community-led initiatives in Chico, California, where donated clothing was organized in tem-

porary distribution centers. However, the destruction of homes and property hindered reconstruction efforts. In contrast, China's post-disaster reconstruction and resettlement processes are more efficient. Press conferences were held to investigate the forest fire incidents, with a dedicated team formed to probe the Liangshan County fire. It was found that the fire resulted from power failures due to specific wind directions, leading to accountability measures for relevant personnel.

Similarly, the investigation of the California forest fire revealed poor management of power lines and facilities by the Pacific Gas and Electric Company. This mirrors the findings in Liangshan Prefecture, where inadequate infrastructure contributed to the fire incidents.

5 Summary and insights

Comparing emergency management of forest fires in California and Liangshan Prefecture reveals strengths and weaknesses. Analysis yields the following insights:

5.1 Strengthening forest infrastructure construction

In recent years, the issue of aging infrastructure has become more pronounced, particularly evident in California due to forest fires highlighting the problem. China faces similar challenges, especially in remote mountainous areas where major forest fires often occur. Inadequate infrastructure hampers firefighting rescue operations, making forest fire emergency management challenging. Therefore, it's crucial to increase funding for forest fire prevention, improve infrastructure, ensure accessible forest roads, enhance communication in fire-prone areas, and strengthen fire warning and monitoring systems.

5.2 Strict implementation of responsibilities and strengthening emergency management responsibilities

Each responsible unit should place forest emergency management work in a prominent position, establish and improve detailed and operable emergency plans, establish a sound, efficient, and information-transparent forest emergency command system, implement and improve regulations and systems, initiate a daily zero-reporting system, and form a unified command. Implement efficient forest emergency disposal operation mechanism. Implement the principle of the main leaders taking overall responsibility, the responsible leaders taking specific responsibility, and the specific personnel taking personal responsibility for forest emergency work in their jurisdictions.

5.3 Accelerating the research and development process of advanced firefighting and rescue equipment

Utilize modern technology to develop advanced firefighting equipment for forests, enhancing capabilities. Improve ground equipment and design specialized vehicles for

different terrains. Foster collaboration between aerial and ground units for maximum efficiency.

6 Conclusion

This paper discusses forest fire situations and emergency responses in China and abroad. In Liangshan Prefecture, China, the focus is on rescuing lives and property through methods like ground spraying. In California, USA, controlling fires with advanced equipment like helicopter foam drops is prioritized. A comparative analysis reveals differences in strategies, means, and effectiveness. Suggestions include strengthening emergency teams and promoting advanced technologies in China, and enhancing monitoring systems abroad. These insights aim to improve global forest fire response efforts.

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