Study on disaster prevention system in key areas of urban forest park with multi-factor coupling-- Chengdu Longquan Mountain as an example

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Abstract. Urban forest parks are major ecological sites in the suburban areas of large cities with good forest vegetation and forest ecological environment, providing people with recreation, tourism, fitness and other suburban activities, and are an important component of the urban landscape system. The spatial density and development intensity of people, facilities and places in the park are higher than those in general forest areas, and the risk of forest disasters is high. To effectively prevent the occurrence of forest disasters and ensure the safety of touring, this paper takes Chengdu Longquan Mountain Forest Park as an example, and divides the key areas of the forest park into high risk areas, medium risk areas and low risk areas through coupled analysis of forest fire risk factors, forest pest risk factors and geological disaster risk factors, and builds a system of prevention, prevention, resistance and rescue for different risk levels. The system is a combination of prevention, resistance and rescue, with points leading to lines, and lines leading to surfaces, forming a disaster prevention system that combines "points, lines and surfaces", with human, physical, technical and institutional prevention complementing each other, providing a model for reducing the risk of disasters and ensuring the health and safety of forest parks.

1. Introduction
In May 2019, the Opinions of the Central Committee of the Communist Party of China (CPC) and the State Council on Establishing a National Land Spatial Planning System and Supervising its Implementation were officially released. The Opinions clearly mention the need to adhere to the concept of "the community of life in mountains, water, forests, fields, lakes and grass" and "the scientific layout of production space, living space and ecological space is to accelerate the formation of green production and lifestyle and promote the construction of ecological civilisation". In the community of life of mountains, water, forests, fields, lakes and grass, forest resources are the mainstay of the terrestrial ecosystem and an important part of the natural geographical pattern on which human beings depend. On the basis of protecting forest resources, forest parks make full use of the various ecological functions of forests and provide tourism services and scientific and cultural activities for people. With the continuous promotion of China's new urbanisation process, the construction of urban forest parks has become one of the important carriers of high-quality development of urban and rural environments, and is an extension of urban life. The spatial density and intensity of development and the openness of the park are higher than those of ordinary forested areas, and various safety incidents such as forest fires, forest pests and diseases, flash floods,
landslides and secondary disasters also occur. At present, the main focus of urban green spaces in China is on the prevention of earthquakes, fire, flood, drought and wind [1]. Since the Wenchuan earthquake in 2008, there has been a gradual increase in the number of research articles on disaster prevention and avoidance green spaces. Some researchers have taken the theoretical construction and case practice of disaster prevention green spaces at home and abroad as an entry point to interpret the current situation of the construction of disaster prevention green spaces in China and put forward ideas for the construction of urban disaster prevention green space systems [2-5]; some researchers have started from the layout of urban disaster prevention green spaces and put forward suggestions on how to optimise them [6-7]; more researchers have evaluated disaster-proof green spaces in specific cities and searched for countermeasures [8-10]; in addition, the state has incorporated disaster-proof green spaces into urban green space design specifications [11]. However, in the planning and management of forest parks, there is little research on how to give full play to the ecological and landscape benefits of forest resources and strengthen the planning and construction of disaster prevention and mitigation systems in forest parks. It is necessary to build up the basic surface of the material carrier of the resilient security defence of urban forest parks through the technical means of territorial spatial planning, to enhance the "resilience" against disasters, to ensure and implement various public service facilities at all levels needed for disaster prevention and control in space, to improve the social governance capacity to deal with disasters, and to do a good job in the prevention and control of forest fires, forest pests and diseases, geological disasters and other high-risk disasters. The prevention and control of high-risk disasters such as forest fires, forest pests and geological hazards is of great importance in improving the level of forest protection and ensuring the safety of tourism.

2. Overview of Chengdu Longquanshan Forest Park

Longquanshan Urban Forest Park is located in the new eastern district of Chengdu and is positioned as a "world-class urban green heart and a national ecological living room", a major project in the construction of Chengdu's park city. The park covers a total area of 1275 square kilometres and involves six districts (cities) and counties in Chengdu, carrying six main functions: ecological conservation, leisure tourism, sports and fitness, cultural display, high-end services and external communication. Wanxing Area is located in the eastern part of Longquanyi District, Chengdu, in the hinterland of Longquan Mountain Range, which is a deep hill and mountainous area with a complex topography. It is a mountainous forest landscape area in the middle section of Longquan Mountain Urban Forest Park, with forest recreation and mountain sports as the main functions.

The Wanxing area is heavily wooded, with natural secondary forests, artificially planted tree forests and sparse grass slope vegetation, cypress forests, alder forests, and patches of bamboo forests. Since 2017, in order to protect the fragile ecological environment of Longquan Mountain and achieve a fundamental change in the urban-rural spatial transformation and production and lifestyle of local residents, the Wanxing area has started to close the mountains for forestry and began to implement the ecological migration relocation project for the whole township and the project to return farmland to forest. With the implementation of the relocation project, the forest area of Longquan Mountain has been increasing and the ecological environment has been significantly improved. 79.93% of the forest was covered in 2019. Wanxing Area has formed a large uninhabited area after the aborigines moved out, the countryside is gradually decaying, and there is a lack of water supply, power supply, firefighting, transportation, communication, medical and other supporting facilities and emergency supplies reserves. There are now water supply plants, sewage treatment plants, cemeteries in Wanxing Township, the Chengdu Chang'an Intravenous Industrial Park and enterprises such as the Chengdu Renewable Energy, Environmental Protection Technology and Solid Waste Sanitary Treatment Site. The scattered distribution of various pipelines in the district has increased the risk of forest disasters, and the construction of a disaster prevention system for the forest park has become a priority.
3. Coupled assessment of multiple risk factors in key areas of urban forest parks

3.1. Selection of assessment factors

There are many disaster risk factors affecting the safety of urban forest parks, such as forest fire, pest and disease risk, geological disaster risk, earthquake risk and flood risk. Risk assessment is an important basic task to protect the ecological environment of urban forest parks and to ensure the safety of visitation by combining the physical and geographical background characteristics of urban forest parks and assessing the level of risk factors.

3.1.1. Forest fire risk factors. Four categories of factors, such as slope, slope direction, vegetation type and fire source, were selected for the Wanxing Area to analyse and assess the risk of forest fires in Wanxing Township, supported by GIS technology and assisted by remote sensing technology. According to the different slope, slope direction and vegetation type and fire source the Wanxing area was divided from the forest fire prevention level into three risk areas: Class I high risk area, Class II medium risk area and Class III general risk area. The areas where high-voltage power lines and oil and gas pipelines pass through, as well as areas near important storage facilities such as waste treatment plants and ritual sites connected to woodlands were added to the original risk level by one level (Table 1).

| Risk class          | Slope orientation                  | Vegetation type and fire source           |
|---------------------|------------------------------------|------------------------------------------|
| Class I: High areas | Sunny slopes and semi-positive slopes at >24° | Areas dominated by coniferous and mixed coniferous forests |
| Class II: Medium area | Sunny slopes and semi-positive slopes with slopes of 14-24° | Dominated by scrub and broad-leaved forests |
| Class III: General area | Slopes up to 14°                  | The rest of the woodland                 |

3.1.2. Forest pest and disease risk factors. The main factors influencing the occurrence, spread and disaster of forest pests and diseases (i.e. environmental factors, pest and disease source factors) and the condition of forest resources (forest cover, proportion of area of host tree species and degree of depression, etc.) are used as the basis for risk assessment of forest pest and disease occurrence, and are divided into Class I key monitoring areas, Class II secondary key monitoring areas and Class III general monitoring areas according to risk levels. The pest and disease source factor is the dominant factor in forest pest and disease risk assessment, while the terrain and topography factor, climate factor and forest resource status are the main basis for assessing the risk of major forest pests and diseases. Forest areas near high-voltage power line corridors are prone to pests and diseases because they are inaccessible to helicopter flight control, and are classified as Class I priority monitoring areas (Table 2).

| Monitoring class            | Altitude               | Vegetation type                                      |
|-----------------------------|------------------------|------------------------------------------------------|
| Class I Key monitoring area | Altitude above 700m    | Areas of sparse pure cypress forest below 0.5 densities |
| Class II Sub-focused monitoring area | Below 700 m altitude | Areas of pure cypress forest with a denseness of 0.9 or less |
| Class III general monitoring area | Below 700 m altitude | Remaining forest land                                 |

3.1.3. Geological hazard risk factors. The stratigraphic lithology of the Wanxing area is relatively homogeneous and the geological structure is relatively simple. According to the statistics of the geological hazard survey, there are 209 geological hazards, mainly landslides. Among them, 147 are landslides, 29 are cave-ins and 33 are unstable slopes. The scale of geohazard development is mainly
small, with the number of small disasters at 201. Based on the environmental elements and triggering factors for the occurrence of geological hazards, as well as information on historical landslides, collapses, unstable slopes and data analysis of disaster-bearing bodies, the geological hazard risk zones are classified into four levels of areas: high susceptibility, medium susceptibility, low susceptibility and very low susceptibility. Based on the data analysis and field calibration, the geological hazard susceptibility of the Wanxing area based on slope units was assessed (Table 3).

| Risk level                          | Area       | Zoning basis                                                                 |
|------------------------------------|------------|------------------------------------------------------------------------------|
| High Vulnerability Zone            | 1.95km²    | Environmental elements, triggers, historical landslides, landslides,         |
|                                   |            | unstable slope information, hazard-bearing bodies                             |
| Medium Vulnerability Zone          | 7.09km²    |                                                                               |
| Low Vulnerability Zone             | 18.59km²   |                                                                               |
| Extremely Low Vulnerability Zone   | 24.50km²   |                                                                               |

3.2. Coupled analysis of multiple risk factors in urban forest parks

On the basis of single-factor multi-factor evaluation, the results of the assessment of the main types of disasters in the Wanxing area, such as forest fires, forest pests and diseases, geological hazards and floods, were superimposed and coupled, and the activity patterns of the population were integrated to divide the township into comprehensive disaster high-risk areas, comprehensive disaster medium-risk areas and comprehensive disaster low-risk areas. The high-risk areas are mainly located in the northern part of the commune where geological hazards are highly prone, and in the central and eastern edges where forest fires are prone.

![Figure 1. Construction of a disaster prevention system for urban forest parks.](image-url)
4. Construction of a disaster prevention system for key tourist areas

Based on the comprehensive disaster risk distribution in the Wanxing area, combined with factors such as safety production, crowd touring, traffic organization and topography, the basic principle of "leaving white and increasing green", according to the development law of the forest tourism product market in Longquan Mountain and the distribution of landscape resources, combined with the current and future period of tourism market demand, the development On the basis of disaster risk assessment and the functional positioning of the Wanxing area of Longquanshan Urban Forest Park, the area is divided into three main functional areas: ecological restoration area, production control area and scenic touring area, based on the principle of "forest as appropriate, tourism as appropriate and industry as appropriate". The three main functional areas are Prevention is the main focus, and prevention, resistance and rescue are combined to form a disaster prevention system that combines points, lines and surfaces, with human, material, technical and institutional prevention complementing each other (Figure 1).

4.1. Ecological restoration areas

The main ecological and environmental problems that need to be addressed in the Longquanshan Urban Forest Park include the structural fragmentation and functional degradation of the ecosystem, inadequate management and protection of various types of protected areas, shortage of water resources, ecological disturbances caused by the development of urbanisation and industrialisation, historical legacy of urban development layout and environmental problems of scattered polluting enterprises. In order to protect the ecological environment of Longquanshan Urban Forest Park, areas such as important areas for biodiversity conservation, important areas for soil and water conservation functions, important areas for water containment and sensitive areas for soil and water erosion are designated as core ecological protection areas, covering an area of 11.87 square kilometres, and some nature reserves, scenic spots, protected areas for drinking water sources, ecological public welfare forests, shorelines, important lakes and reservoirs, various local laws and regulations and other documents that need to be protected are designated as the general ecological space of Longquanshan Urban Forest Park, with an area of 1,161.23 square kilometres [12]. The ecological restoration area is mainly located in the Wanxing Area, which has been designated as a core ecological red line protection area and a key area in the general ecological space where the structure of the ecological system is broken and its function is degraded and in urgent need of restoration.

The ecological restoration zone mainly includes areas at high risk of comprehensive disasters, as well as areas in need of ecological restoration and cultivation, such as sparse forest land, unstocked afforested land, other woodland without standing trees and low-quality forested land. This area is to be closed to forestry and strictly prohibited to human activities. On the one hand, the self-regulating and self-organising capacity of the forest ecosystem should be relied upon to allow it to evolve in an orderly direction and restore the original virtuous cycle of habitats. On the other hand, the existing disaster hazards should be gradually eliminated and secondary disasters avoided through certain physical and engineering measures, such as forest transformation projects, biological control projects and ground disaster management projects.

4.2. Production prevention and control areas

The production prevention and control zone mainly include areas such as renewable energy, environmental technology companies and solid waste sanitary disposal sites distributed in the Wanxing area. The zone focuses on preventing the occurrence of production safety accidents, building a good ecological buffer zone, improving the environment around the park, purifying the atmosphere, water system and soil pollution, effectively isolating the environmental impact of the treatment and disposal projects in the park on other areas, and at the same time focusing on solving the problems of insufficient vegetation biodiversity and poor landscape effects. As far as the current situation is concerned, the flora of Longquanshan Urban Forest Park is still at the basic stage of ecological
restoration and ecological cultivation, and the overall quality is poor, with the flora improving local climatic effects not obvious [13].

Based on the topographic and geomorphological characteristics of Wanxing Township, the north-south ridge line on the west side of the township will be used as the boundary to set up an ecological buffer zone to further reduce the impact of production projects on other areas. Within the ecological buffer zone, the construction of tourism projects and public facilities will be restricted; ecological conservation will be carried out, and the current timber and protection forests will be restored by the vegetation system itself; the current economic forests will be mainly planted with trees such as eucalyptus and cypress, and the ecosystem will be gradually restored by planting other trees such as cycad, balsam fir, heather, giant eucalyptus and poplar, supplemented by shrubs and herbs; other areas with a low vegetation cover coefficient will be restored by In other areas with low vegetation cover, ecosystem cultivation and protective forestry are carried out to increase the vegetation cover and ecosystem stability.

4.3. Scenic excursions
It mainly includes recreational tour areas that are accessible to the public and tourists, in addition to ecological restoration areas and production areas. The comprehensive disaster risk in scenic excursion areas is relatively low, and the main focus is on preventing man-made forest fires, strengthening forest fire monitoring and early warning, and planning and building supporting facilities such as forest fire isolation, forest fire water sources and firefighting facilities. Refine the system for setting up places of refuge and evacuation routes, and strictly control important public buildings and lifeline projects.

5. Conclusions
In the context of the ecological civilisation construction of "ecological priority and green development", the protection of natural resources has become a core element of the territorial spatial planning system, which is the focus of creating a better living environment and promoting sustainable development of human society. As an important part of the spatial ecosystem of the country, urban forest parks, in the process of planning, construction and management, should fully understand the local climate, geological structure, soil and vegetation conditions, as well as the main types of local disasters, and according to the actual situation of the park to prevent hazards and adapt to local conditions. The construction of a comprehensive disaster prevention and mitigation system should be strengthened and incorporated into the territorial spatial planning system. On the basis of a full understanding of the natural geography of the park and the distribution of forest phases, the scale of the park, the capacity of visitors and the potential types of disasters should be carefully analysed, priorities should be distinguished, prevention and control planning should be done well in advance, with the main types of disasters as the key prevention and control targets, and specific countermeasures should be proposed, so that prevention and control can be made in accordance with the hazards and local conditions. In addition to providing a healthy leisure and health resort for human beings, the park will build a disaster prevention system that combines prevention, resistance and rescue, and will do a good job in preventing and controlling forest fires, geological disasters, forest pests and other disasters to ensure the normal functioning of the urban forest park.

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