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Ecological Environmental Protection and Sustainable Development of Wulingyuan Scenic and Historic Interest Area, a World Natural Heritage Site

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ABSTRACT
As a World Natural Heritage Site, Wulingyuan Scenic and Historic Interest Area has a unique and intact ecological environment with high environmental value. This paper first analyzes the natural conditions, ecological characteristics, and existing protection measures of the Wulingyuan Scenic and Historic Interest Area. On this basis, this paper puts forward the problems of ecological protection in the Wulingyuan Scenic and Historic Interest Area, such as the contradiction between regional development and environmental protection and the impact of the growth in the number of tourists on the environment. In order to promote the sustainable development of Wulingyuan Scenic and Historic Interest Area, this paper puts forward the following suggestions: improve the scientific and reasonable management of tourist carrying capacity; implement eco-tourism; strengthen environmental monitoring and biodiversity protection; promote the transformation of the livelihood of local residents; and raise awareness of environmental protection. This paper hopes that analyzing the current situation, comparing experiences, identifying problems, and proposing countermeasures will provide a reference for the ecological protection and sustainable development of the Wulingyuan Scenic and Historic Interest Area. In the future, all parties should realize the harmonious coexistence of humans and nature and promote the sustainable improvement of the ecological environment of Wulingyuan Scenic and Historic Interest Area and other World Natural Heritage Sites to make its environmental value and protection more significant.

KEYWORDS
World Natural Heritage; Wulingyuan Scenic and Historic Interest Area; Ecological Diversity; Conservation and Management and Sustainable Development

1 Introduction

World Natural Heritage is the common natural wealth of mankind, in which biodiversity and ecological integrity have important scientific, cultural, educational and ecological values. [1] However, many World Natural Heritage properties face threats to their ecosystems from human activities. In order to protect these heritages, UNESCO adopted the Convention Concerning the Protection of the World Cultural and Natural Heritage in 1972, which requires governments to take measures to protect their World Natural Heritage. At the same time, local governments also need to formulate relevant regulations to plan and manage the land use and resource development in the areas surrounding the World Natural Heritage, so as to promote the protection and sustainable development of the World Natural Heritage.

Wulingyuan Scenic and Historic Interest Area is located in Zhangjiajie City, Hunan Province, China. On December 14, 1992, Wulingyuan Scenic and Historic Interest Area was inscribed on the UNESCO World Heritage List for meeting the selection criteria for World Heritage Sites (vii), making it one of the second batch of World Natural Heritage Sites to be inscribed in China, and in 2004 it was inscribed on the list of UNESCO's National Geoparks. Its unique landforms and ecosystems are rich in natural resources and biodiversity, and are important for scientific research, environmental education and the development of eco-tourism. In order to protect the ecological environment of Wulingyuan, it is necessary to strengthen the planning and management of the surrounding areas, strictly evaluate the environmental impact, control the construction projects, rationally utilize the resources and promote the sustainable development of tourism. The local government should also formulate regulations, take into account the natural conditions and conservation needs of Wulingyuan, and plan from the perspective of conservation and sustainable development to achieve ecological civilization in the Wulingyuan area. Through the protection of world natural heritage such as Wulingyuan, its ecological value can be sustainably utilized to satisfy the needs of the present generation as well as to protect the interests of future generations.

2 General information

2.1 Overview of the study area

The geographic coordinates of Wulingyuan Scenic Area are 29°19'59.988 ″N, 110°30'0 ″E (Figure 1).

The Wulingyuan Scenic and Historic Interest Area is located in Hunan Province, China, and it covers a total area of more than 26,000 hectares. The area consists of a spectacular landscape of about 3,000 narrow sandstone pillars and steep peaks over 200 meters high. The peaks are dotted with gullies, ravines, streams, pools and waterfalls, and boast some 40

caves as well as two large natural stone bridges. In addition to its stunning natural beauty, the Wulingyuan Scenic Area is also an important biodiversity reserve, as it is home to many endangered plants and animals. The site's unique topography and ecosystem make it both a beautiful and precious World Natural Heritage site. [unesco]

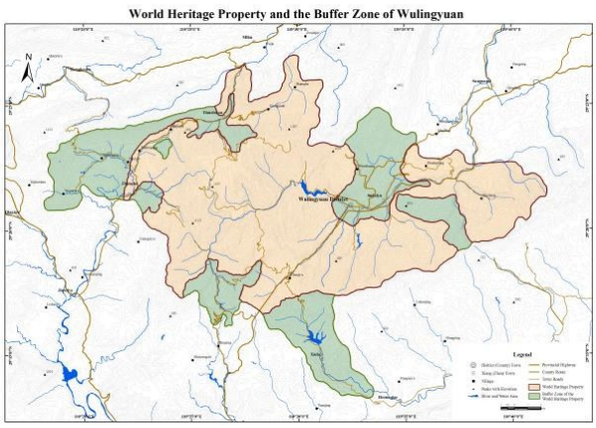

Figure 1

Figure 2 Geographic location charts/notes

The Wulingyuan area has a meso-subtropical mountainous climate with favorable climatic conditions. The climate of this place is moderate and humid, with obvious changes in the four seasons, plenty of rainfall, and no extreme heat or cold. Specifically, the average annual temperature at Suoxiyu in the east is 13.4° C, with maximum and minimum temperatures of 24.3°C and 2.6°C, respectively, and the annual precipitation ranges from 1,380 to 1,450 mm, increasing slightly with elevation. There is a freezing period of about March in areas above 1000 meters above sea level, with 5-11 snow days per year and a snow depth of about 20cm, and a frost-free period of 240-300 days per year. In the west, the topography of the Badaigong Mountainous Region is high, and the terrain slopes from northwest to southeast, with most of the gullies facing southeast. This geographical layout favors the entry and stay of humid air currents, which makes rainfall more abundant in this region. The average annual rainfall in the Badaigong Mountains reaches 2105.4mm, with a maximum of 2840.1mm, 176 rainy days, and an average increase in precipitation of 79.3mm for every 100 meters of elevation. the average annual relative humidity in this region is over 90%, and there are 145 days of foggy days, which makes the conditions of precipitation excellent and favorable for biodiversity. In terms of climate, this region is not extremely hot. The temperature in summer is similar to that of temperate regions, but the coldness in winter is less than that of temperate regions. [2]

2.2 Characteristics of the Main Heritage Resources of World Natural Heritage in Wulingyuan Scenic and Historic Area

Wulingyuan is one of the 11 key areas for biodiversity conservation identified by the China Biodiversity National Situation Study Report in the mainland part of China, and is also one of the core areas of the Wuling Mountain Region Biodiversity and Soil and Water Conservation Ecological Functional Area in the National Main Functional Areas Plan, which is one of the national key ecological functional areas.

Geology and Geomorphology: The three most prominent types of landforms in the Wulingyuan area are sandstone peak forests, tuff karst canyons and tuff karst caves. Zhangjiajie, Tianzishan, Suoxiyu and Yangjiajie are mainly peak forests composed of quartz sandstone, while the gray rock karsts are mainly distributed in the Maoyan River and Tianping Mountain areas in the upper reaches of the river. Where there is a distribution of chert, the scattered appearance of karst

caves can be seen. The common features of the whole region are peculiar peaks, deep ravines, steep cliffs and fast flowing streams. [3]

Geology and tectonics: The Wulingyuan area is located in the northeast of the ancient land mass of the Yunnan-Guizhou Plateau, in the upstream area of the river basin in Hunan Province, and also in the watershed zone of the Qingshui River basin in Hubei Province. In terms of geological composition, the area is mainly composed of Paleozoic sedimentary rocks and a part of sedimentary metamorphic rocks. [2]

Animal resources: In the fauna species, 195 species of vertebrates have been recorded, containing 19 amphibians, 39 reptiles, 91 birds, 46 beasts and 540 insects. [4]

Plant resources: in the flora species, 1630 species (194 families, 746 genera) of vascular plants have been recorded, which contain more than 190 species of ferns, 32 species of gymnosperms, 1415 species of angiosperms, and there are about 770 species of woody plants in the territory. [4]

Cultural Resources: Wulingyuan is rich in cultural resources, including neolithic remains, Ming and Qing exploration literature, and memorial sites of the Red Army's Long March Revolution, etc., with representative examples such as Tujia hammock, Doktor culture, and the Long March Memorial Hall.

3 Problems Facing Ecological Environmental Protection in Wulingyuan Scenic Area

There's a lot of threats.

Flood disaster: Wulingyuan is located in the subtropical area, with abundant precipitation and frequent rainstorms, which is very easy to cause flood disaster, bringing hidden danger to the scenic environment and tourists' safety.

Mudslide: The scenic area is full of gullies and ravines, with steep terrain and column peaks. Due to the concentration of heavy rainfall, short catchment time, coupled with the rock wall collapse of more mud and rocks, mudslide disasters occur from time to time, the scenic area and tourists cause certain hazards.

Landslide: Due to the existence of a large number of alluvial layers, accumulation areas and fracture tectonic zones in the scenic area, these geological structures are relatively loose, and are very likely to cause landslides, threatening the safety of tourists and the ecological environment of the scenic area.

Collapse: Although there is no large-scale collapse event in the scenic area, the phenomenon of single or multiple large rock blocks falling is more common, especially the fall of the rock at the top of the peaks will cause damage to the vegetation below and the local ecology.

Earthquake: Wulingyuan is located in the area of frequent geological activities, there is a potential risk of earthquakes. 2001 February 14, Cili and Sangzhi junction had a 2.5 magnitude earthquake, showing that the region has a certain seismic activity may be.

Forest fires: Although there have been no large-scale forest fires or fire accidents causing serious economic losses in the scenic area, fire incidents are frequent, especially in the peripheral protection zone. The main reasons are the burning of barren land by local residents as well as the increase of tourists and infrastructure construction leading to complex fire sources, and the thick and dense dead branches and leaves in the forests, which are potential fire hazards. In the event of a fire, the consequences will be very serious.

In addition to natural disasters, Wulingyuan's natural environment and biodiversity are facing serious threats. First of all, indiscriminate logging and illegal hunting of wild animals have damaged the local ecological balance, such as the widespread hunting of medicinal fish in the Golden Whip Stream. Infrastructure and buildings in scenic spots have been damaged in terms of biodiversity and natural landscape due to lack of scientific planning. With the rapid development of the tourism industry, the vegetation of the forest park has been damaged to varying degrees, and the fluoride and sulfur dioxide content of fir, willow, maple and poplar has increased significantly, and the growth of fir has been inhibited.

The urbanization and commercialization of scenic spots are prominent, in sharp contrast to the natural ecological environment. Scenic spots such as Ten Mile Gallery and Tianzishan Mountain are filled with a large number of commercial facilities, such as Internet cafes, restaurants and souvenir stores, and new scenic spots such as Yuanjiajie and Huangshizhai have gradually been encroached upon by man-made buildings, and excessive commercialization has had a serious impact on the original natural landscape of the scenic spots. With the advancement of various festivals and infrastructure construction, the increase of motor vehicles and people flow has further increased the pressure on the ecological environment of the scenic spots.

With the increase of tourists in Wulingyuan Scenic Area, its water quality deteriorated significantly. According to statistics in 2000 by Zhangjiajie gong tower, the number of tourists into the scenic area has reached 1.68 million, according to 1 million people to calculate the theoretical value of sewage discharge, the daily discharge of five-day biochemical oxygen demand (BOD_5) 94.5kg, permanganate index of 63kg, according to the ground water level one standard measure of the BOD_5 is standardized load is $9.45 \times 10^4 m^3 / d$, and this section of the Golden Whip Creek during the period of abundance of water each day and night The water flow is 3.4×10^4 to $8.6\times10^4 m^3$, and the minimum flow is

$0.1\times10^4 m^3$ [5] Sewage treatment facilities are only installed by individual units with buried non-powered domestic sewage treatment devices, and the water quality of Jin Whip Creek has deteriorated significantly. The original clear riverbed has a layer of adhesion showing obvious organic pollution. [6]

Furthermore, the heritage resources protection funds are seriously insufficient. Wulingyuan's financial income depends mainly on ticket income and taxes, two-thirds of the ticket income and resource use fees are all paid, the remaining funds can only maintain the basic management personnel wages and social stability and maintenance. Scenic spot annual heritage protection and infrastructure construction funds demand more than 100 million yuan, and most of the funds need to rely on bank loans and subsidies from higher levels, and ultimately left the heritage protection of the funds is minimal.

Tourism practitioners and managers in the scenic area have little knowledge of ecological environment, lack of systematic training and publicity and education, and weak awareness of ecological protection. Many practitioners are aborigines and fail to establish the concept of ecological protection, while some managers lack practical awareness of sustainable development, green tourism and other knowledge. Tourists' awareness of environmental protection also needs to be improved, littering and destroying the environment of scenic spots are common.

Finally, the heritage protection and management system of Wulingyuan still needs to be improved. The current management model has problems such as multiple management, unclear authority and responsibility, which affects effective protection and management. In addition, the mechanism for protecting the interests of community residents and tourists is not sound, and the problems of comprehensive governance of scenic spots, supervision of the tourism industry and community management have not been effectively solved, and the lagging behind of these management systems directly affects the advancement of heritage protection.

4 Countermeasures for Ecological Environmental Protection and Sustainable Development in Wulingyuan Scenic Area

4.1 Protection strategies that can be improved

In the process of conserving and reconstructing the biodiversity of the Wulingyuan Heritage Site, the basic principles of priority conservation, sustainable utilization, public participation and benefit sharing should be followed. Guided by the theory of ecology, comprehensive attention should be paid to the holistic protection of forest vegetation, wildlife, mountain water sources and ecosystems in the Wulingyuan World Natural Heritage Site, and the mutual integration of biodiversity restoration, protection and sustainable utilization should be promoted. In the process of protection, it is necessary to realize the simultaneous protection of species populations and their habitats, take into account in-situ and relocated protection, and adopt a graded, classified and zoned protection mode based on the resource status and the intensity of development and utilization. Priority should be given to the protection of key species, rare and endangered species, old and valuable trees and pristine habitats that maintain the overall ecological balance; at the same time, species and habitats with important or potential value in terms of diversity, rarity, vulnerability and typicality should be given priority protection. In addition, it is also necessary to build a species resource base and a rare and endangered organisms protection base, carry out monitoring of the environmental quality of Wulingyuan and the dynamics of biological populations, strengthen the construction of the institutional mechanism for biodiversity protection, raise the public's awareness of participation, and encourage the social forces to jointly participate in the protection of biodiversity. Strive to upgrade the biodiversity protection of Wulingyuan to a new level of systematization, standardization, refinement and scientification, to realize the sustainable use of biological resources, to promote sustainable socio-economic development, and to achieve coordination and unity of ecological environment and economy.

4.1.1 Follow international treaties and laws and regulations

Protecting the cultural and natural heritage of mankind is an important international cooperation activity of UNESCO for a long time. Wulingyuan is famous for its unique peak and forest landscapes, ancient and famous trees, as well as rare and endangered plants and animals, which is a precious heritage given to mankind by the earth, and it is our responsibility to protect this heritage. The study should be conducted in accordance with the requirements of UNESCO's Convention Concerning the Protection of the World Cultural and Natural Heritage, as well as relevant national and local laws and regulations, to enhance the awareness of managers and operators of the protection of heritage resources, and to fulfill the responsibility of protecting the authenticity and integrity of the world's natural heritage.

4.1.2 Combination of scientific planning and classified guidance

When formulating biodiversity conservation planning and heritage tourism development planning, the integrity and

continuity of the natural ecosystem should be taken into account, while considering the reality and feasibility of protection, in order to maximize the guarantee of effective protection of conservation objects, and at the same time pay attention to the livelihood security of residents of the surrounding communities. Functional zoning should be carried out for areas with different protection levels, and corresponding protection measures should be formulated to build high-quality scenic area infrastructure and expand tourism space on the basis of protecting natural landscape and biodiversity [7].

4.1.3 Strengthening capacity building for biodiversity protection

Establish a database of local species and an information base of plants and animals in Wulingyuan, and improve the monitoring and management capacity for species diversity protection. Strengthen the construction of scientific research infrastructure, promote the construction of scientific research institutions such as the National Laboratory for Biodiversity and the Breeding Center for Endangered Animals, carry out basic and applied research, and solve key technical problems such as functional zoning of protected areas, habitat quality monitoring and ecosystem restoration techniques.

4.1.4 Carry out rescue projects for rare and endangered species

Strengthen in-situ protection of the Wulingyuan Heritage Site, reasonably carry out relocation protection, focus on the protection of endangered plants in The List of Wild Plants under State Key Protection, and carry out rescue projects for the species' resources, so as to enhance their survival and reproduction capacity. At the same time, protect the habitats of the species, reduce the damage to their living environment caused by tourism development, and accelerate the restoration of the destroyed environment in order to promote the self-propagation of endangered species.

4.1.5 Strengthening scenic area environmental governance and controlling over-exploitation

Strengthening scenic area environmental governance, implementing regional fallowing and reforestation, and optimizing the management order of scenic areas. Promote ecological migration to core scenic spots such as Tianzishan and rectify family hotels and hotels. Strengthen the prevention and control of geological disasters, formulate governance programs, strictly control the over-development of scenic spots, set the capacity of tourists, and prevent environmental damage caused by over-development.

4.2 Innovations - Zonal protection and base protection

4.2.1 Building zoning protection

(1) Core Protection Area

The core protection area of the Wulingyuan Heritage Area is the most important protection area, covering zones of high ecological protection value such as nature reserves, forest parks, ecological corridors and water sources. This area includes the core area of the Wulingyuan Scenic and Historic Interest Area, the Zhangjiajie National Forest Park in Hunan Province, as well as nature reserves such as Suoxiyu, Tianzishan and Yangjiajie. Within this zone, only a small amount of tourism infrastructure and monitoring facilities are allowed to be reasonably installed without damaging the ecological environment. Indiscriminate logging, deforestation, mining and other destructive activities are strictly prohibited, and unauthorized facilities must be gradually removed, while business activities conducive to the quality of the forests are carried out moderately.

(2) Biological Resource Protection Zone

The Biological Resource Protection Zone covers areas rich in biological species resources and with little human interference. The ecological importance of the zone determines the importance of protection, and development activities that may threaten the ecological function must be prohibited, hunting and collecting of wild animals and plants must be strictly regulated, ecological corridors and habitats must be protected, and ecosystem stability must be maintained.

(3) Rare Species Protection District

Rare Species Protection District refers to the independent habitats of a few rare species, and it is recommended to implement closed protection measures to improve the habitat environment. Focus on the protection of rare species such as the baby fish and the red-bellied hornbill. In specific areas, such as Baiheping in Zhonghu Lake, protection zones are designated to provide good habitat conditions. Meanwhile, the protection of rare tree species, such as Wuling Pine and Dove Tree, is strengthened, and species migration corridors are established to enhance biodiversity.

(4) Landscape Protection Zone

The Landscape Protection Zone aims to restore the ecosystem function of Wulingyuan and protect the characteristic

tourism landscape resources. It is prohibited to raise livestock and cut down forest trees in this area, strictly control the scale and number of tourism infrastructure, gradually reduce tourism reception facilities, maintain the authenticity and integrity of the park, and promote the restoration of natural ecological landscapes.

(5) Rare Species Breeding Pilot Zone

The Rare Species Breeding Pilot Zone specializes in endangered species that are difficult to reproduce naturally, and is set up in a suitable area. The area can carry out research on the domestication and breeding of giant salamanders and other species, and at the same time carry out the introduction and domestication of other rare species, with the functions of popular science education and tourism.

4.2.2 Building base protection

(1) Rare and Endangered Wild Plant Garden

Construction plan: Simulate the construction of a rare and endangered wild plant garden at Suoxiyu, with a total area of 1,000 mu (66.7 hectares), for collecting, preserving and displaying key protected plants in the middle-subtropical zone, endemic plants in Hunan, precious medicinal plants and other rare plants. The garden will be a place for teaching, scientific research and rescue of endangered plants. It is required to establish protection facilities, set boundary stakes and plant markers, and build garden paths with specialized management.

Herbarium: A herbarium will be constructed as a scientific research and educational infrastructure, open to tourists and scientific investigation teams. Through various means of publicity, such as objects, specimens and pictures, it will raise public awareness of the importance of endangered plant protection. The herbarium has a planned construction area of 1, 000 square meters and is equipped with specimen production, storage and display rooms, and is managed by professional staff.

Plant Research Center: In order to strengthen the research on old and valuable trees and rare and endangered plants, a plant research center is planned to be established, which will be responsible for resource investigation and archive establishment, and carry out physiological, ecological and introductory domestication research. The research center will be organically combined with the botanical garden and herbarium, with a planned construction area of 2,000 square meters, equipped with necessary instruments and equipment.

(2) Rare and Endangered Wild Zoo

Zoo construction: Based on the existing Monkey Park in Suoxiyu Nature Reserve, it is planned to build a new rare and endangered wildlife domestication and breeding farm in Jundiping, and to expand the domesticated species, such as amphibians and birds. The zoo will become an artificial breeding bank for wild animals, which can be used for scientific research as well as commercial operation for tourists' enjoyment after reaching a certain scale, equipped with necessary domestication and veterinary equipment, and full-time domestication personnel.

Wildlife taxidermy museum: through the physical, specimens, pictures and other exhibition forms, to show visitors the rich wildlife resources in Wulingyuan. The herbarium will have a production room, storage room and display room, with a planned construction area of 1,000 square meters and full-time staff responsible for management.

Rare Animal Research Center: In order to explore the scientific management and protection methods of wild animals, a rare wild animal research center is planned to be established, equipped with professional equipment and technicians to carry out wild animal resource surveys and ecological research, including physiology, reproduction and population ecology. The research center will be equipped with facilities such as laboratories, temperature-controlled rooms and offices.

5 Conclusion

As a World Natural Heritage Site, Wulingyuan Scenic and Historic Interest Area has a unique geographic location and rich biodiversity, and its practice of ecological conservation and management provides an important reference for global natural heritage conservation.

Wulingyuan has obvious advantages in terms of geological formations and biodiversity, and its unique karst landforms and diverse ecosystems make it an important bastion of global biodiversity. Although Wulingyuan's conservation and management measures have been effective, it still faces many challenges. Factors such as air pollution, ground transportation, tourism activities and natural disasters have put pressure on its ecosystem. Its conservation measures appear to be insufficiently systematic and complete in some aspects, especially in terms of regulatory implementation and public participation.

In order to realize the sustainable development of Wulingyuan, the balance between environmental protection and economic development needs to be considered comprehensively. Measures such as strengthening environmental

education, improving laws and regulations, and enhancing ecological benefits are recommended to ensure the long-term protection and utilization of natural heritage. Future management programs should pay more attention to scientific planning and public participation in order to enhance social consensus on ecological protection and promote Wulingyuan to play a more active role in global ecological protection.

In conclusion, the conservation and sustainable development management of the Wulingyuan Scenic Area is not only a responsibility for the local ecological environment, but also a contribution to global biodiversity conservation. Through continuous reflection and optimization of management strategies, Wulingyuan is expected to find a more reasonable path between ecological conservation and sustainable development.

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Reference

[1] Keqin, Sun.Study on Sustainable Development of World Heritage Education in China. Advances in Education.2011,1:29-33.

[2] Changdu Chen., Dihua Li.Biodiversity and ecological integrity of Wulingyuan area in Hunan Province. Journal of Ecology.2003,23:2415-2423.

[3] Ping Chen., Suning Xu.Natural Properties and Geo-Aesthetic Value of Sandstone Peak Forests in Wulingyuan area. Geography and Geographic Information Science.2006,22:81-83.

[4] Jun MA.Research on the Coordination of Biodiversity Conservation and Heritage Tourism Development Under the Background of Ecological and Environmental Threshold - A Case Study of Wuling yuan World Natural Heritage. Hunan Normal University.2016.

[5] Zhangjiajie Environmental Monitoring Station, Zhangjiajie Environmental Quality Report.2001.

[6] Dachun Zhuang., Xiangzheng Deng., Jinyan Zhan. Environmental Quality Assessment of Wulingyuan Scenic Area. GEOGRAPHICAL RESEARCH.2004,23:193-200.

[7] Qinyu Jiang., Guiqing Li., Chaozhi Zhang.50th Anniversary of the Convention Concerning the Protection of the World Cultural and Natural Heritage: Change, Dialogue and Sustainable Development -Review of the First Academic Forum on World Cultural and Natural Heritage. China Academic Journal Electronic Publishing House.2023,8:094-098.