

Biodiversity in Jiugong Mountain National Natural Reserve, China

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Abstract

Due to its special earth history, biodiversity and landscape, the Jiugong Mountain National Natural Reserve, located in the southeast of Hubei Province, is an important biodiversity hotspot in the central Yangtze River Basin. Based on our investigation, it contains rich flora and fauna, especially endangered plants and animals distributed in the Jiugong Mountain National Natural Reserve. Human disturbance, invasion by non-native species and small-size hydropower stations seriously threaten local biodiversity and ecosystem function. We provide an overview of Jiugong Mountain's specialized endangered species (such as *Asarum campaniform* and *Primula hubeiensis*), the threats they face and the protective conservation measures in place better to preserve biodiversity and ecosystem functions. The purpose of this study is to conserve biodiversity in highland areas, such as the central Yangtze River basin, by setting out practical knowledge and conservation measures.

Profile

Protected area

Jiugong Mountain

National Natural

Reserve

Mountain range

Jiugong mountain,
China

Introduction

Mountainous regions cover less than 20% of the earth's terrestrial land surface (Rahbek et al. 2019), however, they support very high global biodiversity: about one third of total terrestrial biodiversity (Fjeldsø et al. 2012; Badgley et al. 2017). Meanwhile, natural products from mountains, such as timber, food, medicine, freshwater and other biological resources provide important support for human well-being and sustainable development (Pender 2004; Payne et al. 2020). However, mountain areas are also sensitive to pressures, such as habitat fragmentation, human disturbance, biological invasion and climate change, which represent serious threats to global biodiversity, ecosystem structure and function and the sustainable development of human society (Jansky et al. 2002; Gong et al. 2019; Peng et al. 2021). Thus, more monitoring and research should be focused on highland regions in order better to protect natural resources in mountainous areas and achieve sustainable development (McCain & Colwell 2011; Zeng et al. 2018; Yang et al. 2022).

China is the third largest country on the planet and contains a large highland area (about 63% of the total area), which supports very high biodiversity (Tang et al. 2006; Mi et al. 2019). The highlands of central China are an important habitat for many endemic and endangered species due to their special climate and geological conditions (a subtropical monsoon climate and a geology little affected by quaternary glaciations) (Wu et al. 2003). Some relict species, such as *Davidia involucrata*, *Cercidiphyllum japonicum*, *Emmenopterys henryi* and *Metasequoia glyptostroboides* survived in these highlands through the quaternary glaciations (Lin et al. 2024). Jiugong Mountain is located in Tongshan, a

county of Xianning City in China's Hubei Province. Due to its special earth history, biodiversity and landscape, it is listed in the inventory of Chinese National Scenic Areas (approved by the Ministry of Construction of the People's Republic of China) and as part of the National Natural Reserve (approved by the China National Forestry Administration), the National Geopark (approved by the National Forestry and Grassland Administration) and the National 4A level Tourist Attractions (approved by the provincial-level administrative departments of culture and tourism) (Jiugong Mountain 2024). However, information about biodiversity in Jiugong Mountain is very limited, hindering effective conservation and management.

This study provides basic information about the status of, threats to and conservation of biodiversity in the Jiugong Mountain National Natural Reserve (JMNNR). We hope that this study provides useful information about and suggestions for the highlands in central China.

Study area

The JMNNR (114°23'35" – 114°43'24" E, 29°19'27" – 29°26'52" E) is situated in the southeast of Hubei Province, China (Figure 1). It stretches from the county of Wuning in Jiangxi Province in the south to the northern edge of the town of Henshitan in the county of Tongshan. In the east, it extends to the Taiping mountain forest station and the western boundary is connected to the county of Chongyang. The total area of the JMNNR is 17,442.92 ha and the forest coverage is about 90.64%. The JMNNR's average elevation is 1,228 m asl, with the peak in Laoyajian at 1,656.7 m. The JMNNR was established in 1981

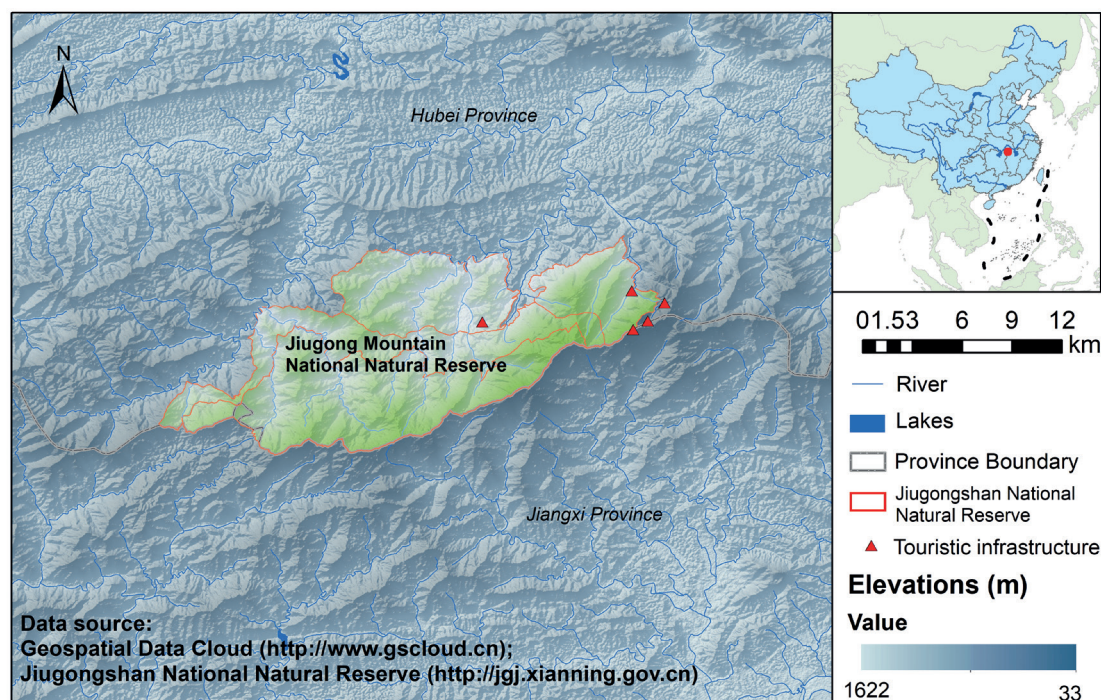


Figure 1— The geographical location and spatial extent of the Jiugongshan Mountain National Nature Reserve

with approval from the Tongshan County People's Government. In 1988, it was upgraded to a provincial-level nature reserve by the Hubei Provincial People's Government. In 2007, it was reclassified as a National Nature Reserve.

Yunzhong Lake is located at the top of Fenghuangling Mountain at an altitude of 1,250 m. Owing to its location on a mountaintop surrounded by clouds, hence its name Yunzhong Lake meaning lake in the clouds. This lake covers an area in excess of 100 acres and is 3.5 m deep on average. Yunzhong Lake is the third largest highland lake in China and its breathtaking beauty attracts many tourists each year.

The climate of the JMNNR is a subtropical monsoon climate. The annual average temperature of the JMNNR increases from 8.8 °C at the southernmost point to 16.7 °C at the northernmost point. The annual average precipitation in the JMNNR is 1,400–2,000 mm (about 73% in the rainy season, February–June, and only 27% in the dry season), with a highest recorded precipitation of 2,199.8 mm in 1973.

Biodiversity

Building on an investigation of non-native species in China from 2003 to 2024 and the work of the undergraduate research training program of Hubei Normal University from 2021 to 2024, we conducted a series of field investigations about biodiversity in the JMNNR. For the detailed investigation methods, see Wang et al. 2021 and Wang et al. 2024. Based on our investigation and a comprehensive literature review, there are 1983 vascular plant species belonging to 209 families and 857 genera, which account for about 7.1%, 59.2% and

27.0% of the total number of plant species, families and genera of China, respectively. There are 37 endangered plant species distributed in the JMNNR (Table 1) with 24 National Key Protected Plants (two Class I species and 22 Class II species), 15 National Precious Tree Species (three Class I species and 12 Class II species) and 25 National Rare and Endangered Plants (10 Class II species and 15 Class III species). There are some endangered species (such as *Asarum campaniforme* and *Primula hubeiensis*) that have only survived in the JMNNR (Wang et al. 2004; Li et al. 2017).

For National Key Protected Plants (National Forestry and Grassland Administration, Ministry of Agriculture and Rural Affairs of the People's Republic of China 2021a), both class I and class II plants have important ecosystem functions, but there are few individuals and the distribution is narrow. However, class II plants are less threatened than class I.

National precious tree plants are species that are scarce in quantity and have high economic value (Zhang 1993). Class I species are prohibited from being cut down, while class II species are strictly controlled. Class I species of national rare and endangered plants are unique to China and have extremely significant scientific, economic and cultural value. They are either endangered or rare species (State Environmental Protection Agency of the People's Republic of China and the Institute of Botany of the Chinese Academy of Sciences 1987). Class II species are declining species of significant scientific and economic value. Class III plants are rare species with relatively lower economic value than class II.

There is a very high amount of fauna biodiversity in the JMNNR, including 48 mammals belonging to

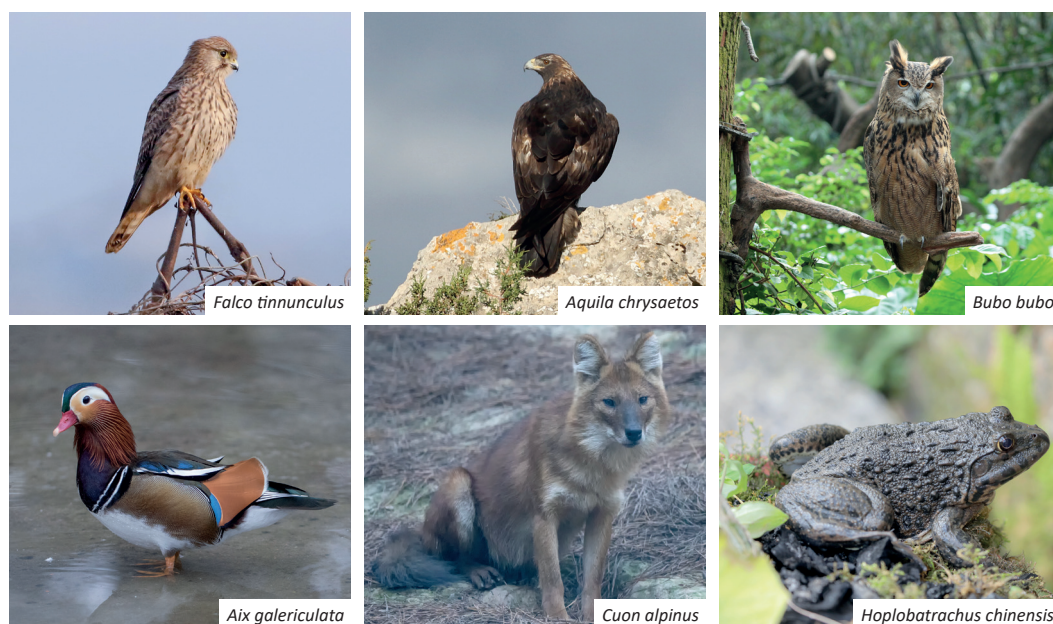


Figure 2 – Some of the protected animals from the Jiugong Mountain National Natural Reserve. © Kai Zhao

seven orders, 20 families and 33 genera; 146 birds belonging to 15 orders, 38 families and 105 genera; 39 reptiles belonging to two orders, eight families and 26 genera; 27 amphibians belonging to one order, six families and eight genera. Of these, 22 animal species have been included in the List of Endangered Animals of China (five Class I species and 18 Class II species) (Figure 2). All the endangered animal species are shown in Table 2.

Class I protected animals are rare species with a small population, which are endangered or nearly extinct in the wild. Class II protected animals are those that are more numerous than Class I animals (National Forestry and Grassland Administration, Ministry of Agriculture and Rural Affairs of the People's Republic of China 2021b).

Threats to the Jiugong Mountain National Natural Reserve

Human disturbance

Human disturbance is an important threat to biodiversity and ecosystems in hilly regions (Yang et al. 2022). The number of local residents increased from 2,846 in 2000 to 42,992 in 2019 (NBS 2020). For basic survival, local residents have to reclaim more land and have planted maize, tomato and some other vegetables. Due to its beauty and long history (as a Taoist holy place for nearly 800 years), almost half a million tourists visit the JMNNR each year. As a result, massive infrastructure, such as roads, housing, water and power supply facilities, has been built over the past twenty years. Now, national and provincial roads cover the county of Tongshan, connecting every village and town. For example, the newly constructed Yunzhong Lake parking area, which is under the management

of the JMNNR Administration, Xianning, Hubei, occupies 12,800 m² at the center of the JMNNR (Jiugong Mountain 2024). Roads, pipes and some human dwellings have fragmented the habitat, significantly influencing the migration and gene exchange of many animals and eventually causing the population decline of many native animals (Eigenbrod et al. 2008; Piano et al. 2020).

Invasion of non-native species

Biological invasion is a serious threat to global biodiversity, ecosystem function and environmental health (Sala et al. 2000; Simberloff et al. 2013). China today is one of the countries seriously threatened by the invasion of non-native species (Xu et al. 2012; Xiong et al. 2015; Wang et al. 2016). Indeed, the middle reaches area of the Yangtze River, where the JMNNR is located, is a hotspot for invasion of non-native species (Xiong et al. 2018, 2023a). Comparing our results with field investigation by the Wuhan Botanical Garden and the China University of Geosciences, we recorded invasion by some non-native species in the JMNNR, including *Sesbania cannabina*, *Alternanthera philoxeroides*, *Erigeron annuus*, *Gambusia affinis*, *Oreochromis niloticus*, *Procambarus clarkii*, *Pomacea canaliculata* and *Trachemys scripta elegans*. In a previous study, we observed that these non-native species have caused significantly negative ecological impacts in surrounding regions (Cheng et al. 2018; Xiong et al. 2019, 2023a). These non-native species caused a sharp decline of native biodiversity and changed ecosystem structures and functions.

Small-size hydropower stations

There are many streams and mountain springs in the JMNNR. In order to provide electricity for rural

Table 1 – The list of endangered plant species in the Jiugongshan Mountain National Nature Reserve.

No	Scientific name	National Key Protected Plants	National precious tree species	National rare and endangered plants
1	<i>Taxus chinensis</i> var. <i>mairei</i>	I	I	
2	<i>Bretschneidera sinensis</i>	I	I	II
3	<i>Cibotium barometz</i>	II		
4	<i>Pseudolarix amabilis</i>	II	II	II
5	<i>Cephalotaxus oliveri</i>	II	II	II
6	<i>Tarrea fargesii</i>	II		
7	<i>Tarrea grandis</i>	II		
8	<i>Liriodendron chinense</i>	II	II	II
9	<i>Magnolia officinalis</i>	II	II	III
10	<i>Magnolia officinalis</i> spp. <i>biloba</i>	II		III
11	<i>Tetracentron sinense</i>	II	II	II
12	<i>Cercidiphyllum japonicum</i> var. <i>sinense</i>	II	II	II
13	<i>Cinnamomum camphora</i>	II		
14	<i>Cinnamomum japonicum</i>	II		III
15	<i>Phoebe zhennana</i>	II	II	III
16	<i>Ormosia henryi</i>	II	II	
17	<i>Glycine soja</i>	II		III
18	<i>Fagophrum dibotrys</i>	II		
19	<i>Zelkova schneideriana</i>	II	II	
20	<i>Toona ciliata</i>	II		III
21	<i>Toona ciliata</i> var. <i>pubescens</i>	II		
22	<i>Camptotheca acuminata</i>	II		
23	<i>Emmenopterys henryi</i>	II	I	II
24	<i>Sinojackia xylocarpa</i>	II		II
25	<i>Tilia tuan</i>		II	
26	<i>Eucommia ulmoides</i>		II	II
27	<i>Kalopanax septemlobus</i>		II	
28	<i>Changnienia amoena</i>			II
29	<i>Magnolia cylindrica</i>			III
30	<i>Coptis chinensis</i>			III
31	<i>Coptis chinensis</i> var. <i>brevisepala</i>			III
32	<i>Stewartia sinensis</i>			III
33	<i>Pieroceltis tatarinowii</i>			III
34	<i>Tapiscia sinensis</i>			III
35	<i>Pterostyrax psilophylla</i>			III
36	<i>Dysosma versipellis</i>			III
37	<i>Gastrodia elata</i>			III

residents, some small-size hydropower stations were built in the JMNNR (Tongshan County Government 2024). In order better to protect local biodiversity and aquatic habitats in the Yangtze River Basin, the Chinese central government issued *Opinions on carrying out the cleanup and rectification of small-size hydropower in the Yangtze River Economic Zone* and asked for the shutdown of all small-size hydropower stations in the core areas and buffer areas of Natural Reserves by December 2020 (Chinese Central Government 2018). However, five small-size hydropower stations remained in operation during 2021 and were only dismantled under the supervision of the central inspectors of environmental protection in 2022 (Network of the Development of the Yangtze River Economic Belt website 2021; Tongshan County Government 2022). A third central government ecological and environmental protection supervision group inspired further local government rectifications and reforms. Natural populations of local

fish, amphibians, reptiles and other biological groups had decreased sharply due to changes in the hydrobiological situation (Xiong & Jian 2009; Lyu et al. 2022).

Protective suggestions

Biological monitoring is an important preliminary measure for biodiversity conservation (Anderson 2018; Köhl et al. 2020). As a geographical and geological shelter, Jiugong Mountain provides suitable habitats for many endangered flora and fauna. Researchers have reported many newly discovered and described species, such as plants (Xie and Mao 2010; Lu et al. 2024) and insects (Zheng & Zhong 2005) in the JMNNR. This shows that there are rich flora and fauna in the JMNNR. Due to the complex geological conditions in many remote regions of the JMNNR, many researchers find it very hard to reach. Some new technology and equipment, such as remote sensing, UAVs

Table 2 – The list of endangered animal species in the Jiugongshan Mountain National Nature Reserve.

No.	Species	Protection class	Biological group
1	<i>Aquila chrysaetos</i>	I	Bird
2	<i>Syrnaticus ellioti</i>	I	Bird
3	<i>Neofelis nebulosa</i>	I	Mammal
4	<i>Panthera</i> Genus	I	Mammal
5	<i>Panthera tigris</i> ssp. <i>amoyensis</i>	I	Mammal
6	<i>Hoplobatrachus chinensis</i>	II	Amphibian
7	<i>Bungarus multicinctus</i>	II	Reptile
8	<i>Manis pentadactyla</i>	II	Mammal
9	<i>Cuon alpinus</i>	II	Mammal
10	<i>Lutra lutra</i>	II	Mammal
11	<i>Martes flavigula</i>	II	Mammal
12	<i>Viverricula indica</i>	II	Mammal
13	<i>Hydropotes inermis</i>	II	Mammal
14	<i>Capricornis sumatraensis</i>	II	Mammal
15	<i>Platalea leucorodia</i>	II	Bird
16	<i>Aix galericulata</i>	II	Bird
17	<i>Accipiter nisus</i>	II	Bird
18	<i>Falco tinnunculus</i>	II	Bird
19	<i>Pucrasia macrolopha</i>	II	Bird
20	<i>Coturnicops eximius</i>	II	Bird
21	<i>Otus sunia</i>	II	Bird
22	<i>Bubo bubo</i>	II	Bird

(Unmanned Aerial Vehicles) and automatic cameras should more widely be applied for the purposes of biodiversity monitoring in this JMNNR (Petrou et al. 2015; Schöttker et al. 2023). However, more specialist training is urgently required, as are more funds, equipment and professional staff.

In particular, there is an urgent need for more funds and professional staff to protect the remaining small populations of some endangered species, such as *Toona ciliata*, *Changnienia amoena*, *Aquila chrysaetos* and *Falco tinnunculus*. Human disturbance has led to the sharp decline and fragmentation of habitats suitable for these endangered species. The numbers of certain endangered species, such as *Neofelis nebulosa*, *Panthera tigris* ssp. *Amoyensis* and *Hydropotes inermis*, have decreased to less than 20 and so they face extinction in the JMNNR. Thus, we call on local government to provide more funds and researchers for the investigation and conservation of these endangered species. Meanwhile, researchers should put more effort into biodiversity conservation and education in order to lessen the damage done by local residents.

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