

Conservation and development of the Daqishan Nature Reserve in Hubei Province, China

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Keywords: biodiversity conservation, forest ecosystem, highland, subtropical monsoon climate, endangered species

Abstract

The Daqi Mountain Provincial Nature Reserve in eastern Hubei Province, China sustains a unique natural forest ecosystem. It is an important reserve for the conservation of several endangered species and is a native highland forest habitat in the mountainous region of central China. Global warming, biological invasions and human disturbance are seriously threatening some of its endemic species and the entire forest ecosystem. Some endangered species, including *Chinemys reevesii*, *Hynobius chinensis*, *Paa boulengeri* and *Falco vespertinus*, have experienced significant stresses and ecological challenges. In order better to protect biodiversity and ecosystem functioning, some measures should be undertaken, including more research and ecological monitoring and the adoption of more reliable fire protection strategies and means of response. We hope that this study can provide useful information for the conservation and management of biodiversity in the forest ecosystems of central China.

Profile

Protected area

Daqi Mountain

Provincial Nature

Reserve

Mountain range

Dabie Mountains,
China

Introduction

Highland ecosystems sustain a high diversity of flora and fauna and a broad array of habitat types (Körner 2004; Perrigo et al. 2020), which support rich resources for human survival and sustainable development such as timber, food, medicine and diverse biological resources (Pender 2004; Rahbek et al. 2019). Global climate change, geological disasters, human disturbance, habitat destruction and biological invasions cause serious threats to these resources (Antonelli et al. 2018; Li et al. 2022; He et al. 2023). Because of these concerns and issues, researchers, governments and local residents direct significant effort to the conservation and exclusively sustainable uses of the biodiversity resources in mountain regions (Chen et al. 2009).

China has a very high number of mountains and large areas of montane regions which support a rich and unique biodiversity (Zhang et al. 2002; Tang et al. 2006). Biodiversity hotspots such as these are important refuges for many relict and endangered species (Mi et al. 2019). For example, the Yangtze River is one of 200 priority regions for biodiversity conservation, providing diverse habitats and sustaining high biodiversity (Olson & Dinerstein 1998). Unfortunately, accurate and current information about biodiversity is scant, which has limited effective management and conservation of biodiversity in some highland regions of the middle and lower reaches of the Yangtze River (Xiong et al. 2024).

Daqi Mountain is in the northeast part of Hubei Province, one of the richest biodiversity areas in Hubei Province with one of the best-preserved stands of forest vegetation in the southern foothills of Dabie

Mountain (Lei et al. 2012). The flora of Daqi Mountain has an ancient origin and is relict in nature. The Daqi Mountain setting concentrates and distributes many families and genera that are ancient in origin and primitive in systematic evolution, and it also contains many relict plants (Lei et al. 2013). For example, its ancient tree group of *Pinus hwangshanensis* are currently the species most well-protected in representative sites in central China.

The objectives of this study are to summarize the current status of the Daqi Mountain Provincial Nature Reserve's biodiversity and the factors influencing it, as well as to recommend appropriate conservation measures. We hope that this study will provide useful information and guidance for local governments and residents to sustain the existing biological resources in the highlands of the middle and lower reaches of the Yangtze River.

Study region

Hubei's Daqi Mountain Nature Reserve (DMNR) is located between 30° 47.57' – 30° 52.50' N and 115° 04.12' – 115° 10.07' E and is in the northern mountainous area of Tuanfeng County, Huanggang City, Hubei Province, China. The total area of the DMNR is 1,753.36 hectares, of which the core area comprises 629.81 hectares and the surrounding buffer area 389.95 hectares (Figure 1). The Daqi Mountain Forestry Farm was initially established in 1957 and the Daqi Mountain Provincial Forest Park was designated in 1993. On 31 May 2013, the General office of the People's Government of Hubei Province approved the establishment of the DMNR, with the primary protected elements being the northern subtropical

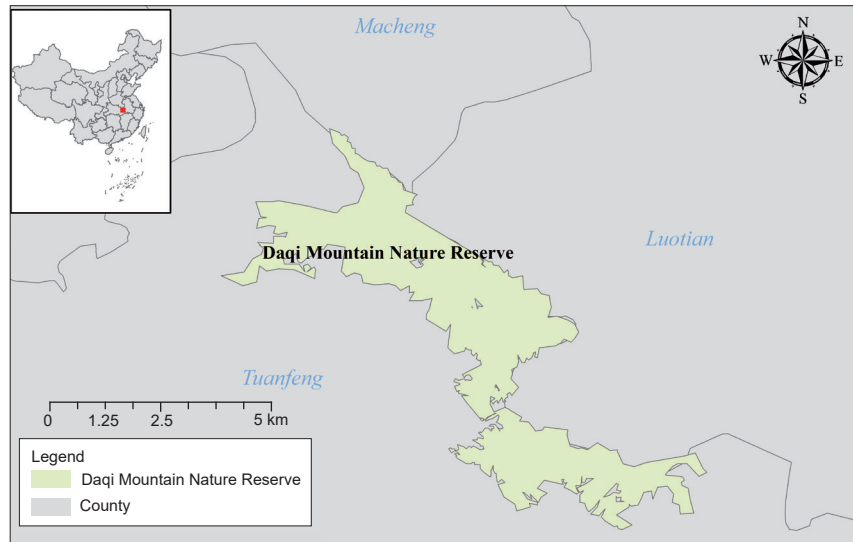


Figure 1 – The location of Daqi Mountain Nature Reserve. Data: Daqi Mountain Provincial Nature Reserve Management Committee.

forest ecosystem, endemic or endangered animal and plant species, such as the golden cat (*Pardofelis temminckii*), the Reeves' pheasant (*Syrnaticus reevesii*), and ancient tree communities of the Huangshan pine (*Pinus hwangshanensis*). The DMNR Management Committee was established in 1999.

The DMNR occupies the southern foot of the Dabie Mountains and the northern bank of the Yangtze River, lying climatically in the subtropical to temperate transition area. The DMNR is in low mountainous terrain with an elevation of 400–700 m. The mountain highland topography is oriented in an east-west direction.

The climate of the DMNR belongs to the subtropical continental humid monsoon climate category characteristic of the middle and lower reaches of the Yangtze River. The average annual precipitation is about 1,262 mm, with the highest reaching 1,784.8 mm in wet years, the lowest measurements of 789.1 mm occurring in dry years. The precipitation is concentrated in April, May and June and it is the lowest in winter. The average annual sunshine is 2,028 hours and the annual frost-free period is about 240 days. The average annual temperature is 16.8°C, the lowest temperatures occur in January, the average temperature is 3.9°C and the lowest temperature is –12.2°C. The highest temperature is in July, the average temperature is 29.3°C and the highest temperature is 40.3°C.

There are no large rivers or reservoirs in the DMNR, but it is the source of two large national reservoirs – the Daoguan River Reservoir in Xinzhou District, Wuhan City and the Niuche River Reservoir in Tuanfeng County. The rivers in the area are the Niuche River, the Bashui River, the Wugui River, the Longtan River and the Zhuizhi River, which all eventually flow into the Yangtze River.

Biodiversity status

Between 2011 and 2018 the authors, together with undergraduate students, conducted botanical and faunistic field practice courses in the DMNR. From 2019 to 2022, the botanical and faunistic field practice had to be cancelled due to COVID-19 restrictions. Unfortunately, in 2023–24, the park infrastructure was dismantled in order better to protect nature and biodiversity in the DMNR (Tuanfeng County Government Website 2024), so, botanical and faunistic field practice could not continue.

During the courses, we carried out various methods of botanical survey. In 2011–14, botanical surveys were conducted along all major tourist routes. In 2015–18, we carried out botanical surveys in 200 line transects (500 m per line). All plant samples were collected and identified according to *Flora of China*. Meanwhile, we conducted faunistic surveys between 2011 and 2018; for the detailed investigative method, see Wang et al. (2021).

Based on our field investigations between 2011 and 2018, there are 1,119 vascular plants species belonging to 581 genera in 168 families that occur in the DMNR. Within this flora there are 72 fern species in 41 genera and 25 families, and 1,047 spermatophyte species in 540 genera and 143 families (including 16 gymnosperm species in 13 genera and 6 families, and 1,031 angiosperm species in 527 genera and 137 families).

There is a high faunal biodiversity in the DMNR including 18 amphibian species (2 orders, 6 families and 8 genera), 29 reptile species (2 orders, 10 families and 22 genera), 144 bird species (14 orders, 37 families and 91 genera) and 42 mammal species (7 orders, 18 families and 35 genera).

It is worth noting that there are a great number of endangered species and ancient trees that have survived in the DMNR. Within the DMNR there are 31

Table 1 – Endangered plant species in the Daqi Mountain Nature Reserve.

No	Scientific name	State key protected plants	National rare and endangered protected plants
1	<i>Ginkgo biloba</i>	I	II
2	<i>Huperzia serrata</i>	II	
3	<i>Magnolia officinalis</i>	II	III
4	<i>Magnolia officinalis</i>	II	III
5	<i>Liriodendron chinense</i>	II	II
6	<i>Cercidiphyllum japonicum</i>	II	
7	<i>Fagopyrum dibotrys</i>	II	
8	<i>Glycine soja</i>	II	III
9	<i>Phellodendron chinensis</i>	II	
10	<i>Panax pseudo-ginseng</i> var. <i>Japonicus</i>	II	
11	<i>Fritillaria anthuiensis</i>	II	
12	<i>Fritillaria hupehensis</i>	II	
13	<i>Paris delavayi</i>	II	
14	<i>Paris polyphylla</i>	II	
15	<i>Paris polyphylla</i> var. <i>stenophylla</i>	II	
16	<i>Bletilla striata</i>	II	
17	<i>Cangnienia amoena</i>	II	
18	<i>Cymbidium ensifolium</i>	II	
19	<i>Cymbidium goeringii</i>	II	
20	<i>Cypripedium japonicum</i>	II	
21	<i>Gastrodia elata</i>	II	
22	<i>Phoebe zhennan</i>	II	III
23	<i>Zelkova schneideriana</i>	II	
24	<i>Emmenopterys henryi</i>	II	II
25	<i>Eucommia ulmoides</i>		II
26	<i>Changnienia amoena</i>		II
27	<i>Pteroceltis tatarinowii</i>		III
28	<i>Stewartia sinensis</i>		III
29	<i>Euptelea pleiosperma</i>		III
30	<i>Litsea auriculata</i>		III
31	<i>Dipteronia sinensis</i>		III

plant (Table 1) and 37 animal species (Table 2) that are listed as Category I and II Protected Species in China. In addition, there are 786 extremely old trees (including *Pinus hwangshanensis*, *Ginkgo biloba*, *Camphora officinarum*, *Pinus massoniana*, *Liquidambar formosana*, *Platycladus orientalis*, *Pterocarya stenoptera*, *Fraxinus chinensis*, *Castanea mollissima*, *Sophora japonica*, *Koelreuteria bipinnata*, *Quercus acutissima*, *Celtis sinensis*, *Quercus glauca* and *Diospyros kaki*) that have survived in the DMNR (including 10 trees over 500 years, 50 trees between 300 and 500 years and 726 trees between 100 and 300 years). Tree age was estimated by means of the relationship between the tree's diameter at breast height (DBH, 14 m height) and its age, inferred from evidence based on ambitus studies in Wuhan (Xiao et al. 2020).

Class I protected plants have important ecosystem functions with relatively few individuals in narrow distribution. These plants receive the highest level of

Table 2 – Endangered animal species in the Daqi Mountain Nature Reserve.

No	Scientific name	Animal group	Endangered status
1	<i>Rana rugulosa</i>	Amphibian	II
2	<i>Chinemys reevesii</i>	Reptile	II
3	<i>Syrnaticus reevesii</i>	Bird	I
4	<i>Emberiza aureola</i>	Bird	I
5	<i>Accipiter nisus</i>	Bird	II
6	<i>Accipiter virgatus</i>	Bird	II
7	<i>Buteo buteo</i>	Bird	II
8	<i>Circus cyaneus</i>	Bird	II
9	<i>Circus melanoleucos</i>	Bird	II
10	<i>Circus spilonotus</i>	Bird	II
11	<i>Milvus migrans</i>	Bird	II
12	<i>Falco columbarius</i>	Bird	II
13	<i>Falco peregrinus</i>	Bird	II
14	<i>Falco subbuteo</i>	Bird	II
15	<i>Falco tinnunculus</i>	Bird	II
16	<i>Falco vespertinus</i>	Bird	II
17	<i>Pucrasia macrolopha</i>	Bird	II
18	<i>Tragopan temminckii</i>	Bird	II
19	<i>Tyto capensis</i>	Bird	II
20	<i>Asio flammeus</i>	Bird	II
21	<i>Asio otus</i>	Bird	II
22	<i>Glaucidium cuculoides</i>	Bird	II
23	<i>Strix aluco</i>	Bird	II
24	<i>Alauda arvensis</i>	Bird	II
25	<i>Garrulax canorus</i>	Bird	II
26	<i>Garrulax elliotii</i>	Bird	II
27	<i>Garrulax ocellatus</i>	Bird	II
28	<i>Luscinia calliope</i>	Bird	II
29	<i>Leiothrix lutea</i>	Bird	II
30	<i>Rhinomyias brunneata</i>	Bird	II
31	<i>Cuon alpinus</i>	Mammal	I
32	<i>Manis pentadactyla</i>	Mammal	I
33	<i>Martes flavigula</i>	Mammal	II
34	<i>Nyctereutes procyonoides</i>	Mammal	II
35	<i>Vulpes vulpes</i>	Mammal	II
36	<i>Prionailurus bengalensis</i>	Mammal	II
37	<i>Elaphodus cephalophus</i>	Mammal	II

protection in China. Class II protected plants have important ecosystem functions also, but are relatively less threatened than Class I protected plants. Class III protected plants require scientific management and rational utilization to ensure the stability of their populations.

Class I protected animals are very few in number and are usually very rare species, many of which are endangered or even nearly extinct in nature. The number of Class II protected animals is relatively high.

Threats

Global climate change

Global warming is recognized as one of the main threats to highland biodiversity (Fashing et al. 2022). Increased warming has changed the spatial distribution of many species within the flora and fauna in the highland regions (Xiong et al. 2023b). Climate warm-

ing has increased wildfire activity in many highland regions (Jones et al. 2022; Senande-Rivera et al. 2022). In interviews with local residents and protected area staff, they reported that there were over 70 wildfires in past 10 years in the DMNR. Although there has not been significant change in the frequency of wildfires, there has been a reduction of 185 hectares of forest cover due to wild fires between 2013 and 2020 (Fu et al. 2020). These wildfires seriously damaged local biodiversity and highland forest ecosystems. Meanwhile, extreme precipitation increased in Eastern Hubei Province, which is the region of the DMNR (Chen et al. 2018). During our field work we observed landslides covering endangered trees, such as *Ginkgo biloba*, *Huperzia serrata* and *Paris delavayi*, which changed ecosystem function and seriously stressed and threatened local biodiversity.

Human disturbance

Human disturbance poses an important threat to highland biodiversity (Yang et al. 2022). The human population increased to 1,542 in 2018, and the density of the human population on the DMNR reached 87 persons/km². Due to the remoteness of some villages within the area, more data are not available. By comparison the population density of the DMNR far exceeds that of other reserves in Hubei Province (20 person/km² in the Shennongjia National Nature Reserve, 26 person/km² in the Jiugong Mountain National Nature Reserve). Before 2002, forestry was the primary industry in the DMNR. A large quantity of forestry products, such as upon wood and seedlings, were gathered from this region and damaged the habitats for some endemic or endangered species. Traditionally, some residents hunted a great number of wild animals (such as *Vulpes vulpes*, *Arotonyx collaris*, *Sus scrofa* and *Muntiacus reevesi*) as food in Daqi Mountain and adjacent regions. And some species, such as *Manis pentadactyla* and *Chinemys reevesii*, have been captured for use in traditional Chinese medicine. As a result, the populations of some endemic or endangered species have declined sharply over the past 40 years (Xiang et al. 2006). Since the establishment of the DMNR hunting has been strictly prohibited. However, some local residents and tourists often collect mushrooms and inevitably destroy local vegetation, animal habitats and shelters. For example, several tons of mushrooms (mainly *Lactarius deliciosus*) have been harvested and removed from Daqi Mountain each year (according to communications with local residents). Now, many local residents depend on the development of tourism services (including the selling of mushrooms) for their survival.

Biological invasions

Biological invasions are one of the primary threats to global biodiversity, ecosystem function, human health and sustainable development (Simberloff et al. 2013). China has introduced a very high number of

non-native species that have become one of the most serious threats to its biodiversity (Xiong et al. 2015, 2017; Wang et al. 2016). The Yangtze River is one of the global invasion hotspots of non-native species and some habitats have experienced an exceptionally high invasion rate by non-indigenous species (Xiong et al. 2018, 2023a). Based upon our investigations, many non-native plant species (*Alternanthera philoxeroides*, *Bidens Pilosa*, *Erigeron bonariensis*, *Erigeron acris*, *Erigeron annuus* and *Solidago decurrens*) and animal species (*Rana rugulosa*, *Rana catesbeiana*, *Gambusia affinis*, *Procambarus clarkii* and *Achatina fulica*) have successfully established feral populations in the DMNR. As a result, some native endemic and endangered species, such as orchid species, amphibians and reptiles, have declined sharply due to competition, herbivory or predation by these non-indigenous species.

Measures for conservation

Long-term monitoring is a very important measure in biodiversity conservation (Ma 2011; Cavender-Bares et al. 2022). Some institutes, such as Huazhong Agricultural University, Hubei Ecology Polytechnic College, and the Hubei wild animal and plant protection station, have conducted field monitoring, pest control and plant identification and taxonomic classification in the DMNR over the past twenty years (Hu et al. 2007; Lei et al. 2013). However, none of these efforts have operated continuously for over five years. China is currently carrying out some large monitoring projects, such as those managed by CForBio (Chinese Forest Biodiversity Monitoring Networks) and NERNC (National Ecosystem Research Network of China), that include monitoring many important highland areas and habitats. New technologies, such as environmental DNA, UAV (unmanned aerial vehicle), remote sensing monitoring and artificial intelligence management, have been widely employed in ecological monitoring (Anderson & Gaston 2013; Willis 2015; Feng et al. 2022). These new technologies require more personnel training, new instrumentation and more funding dedicated to ecological monitoring. It is urgent that local governments better support monitoring resources, including overall funding, human resources and new technologies for long-term monitoring in the DMNR.

Fire is an important threat to biodiversity in some highland regions (Xiao et al. 2022). The DMNR is prone to forest fires. The terrain is high and steep and once a fire occurs, it is difficult to extinguish. Many residents living in the DMNR use field fires for agriculture, which can cause extensive forest fires if a fire escapes. The use of UAVs in monitoring wildfires has expanded the ability to control them (Ollero et al. 2006), and more UAV and professional training should be initiated in support of fire control in the DMNR.

Scientific research is an important protective measure for biodiversity because it provides ongoing and accurate data on many aspects of species habitats, the

condition of their populations and their viability over time (Purvis & Hector 2000). Recently, the populations of some endemic or endangered species (such as *C. japonicum*, *Z. schneideriana*, *P. delavayi* and *P. polyphylla*) have sharply decreased (Lei et al. 2012, 2013). More public awareness of and an emphasis on research regarding the propagation of non-native species through individual propagules, the management of both non-native and endangered species populations and habitat conservation for endangered species is needed. It is essential for local governments and environmental organizations better to support and fund ecological education and research in the DMNR.

Acknowledgements

This research was supported by the Second Tibetan Plateau Scientific Expedition and Research Program (STEP) (Grant No. 2019QZKK0304, 2019QZKK0501), and the National Natural Science Foundation of China (Grant No. 31600189).

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