Comparative Study and Geographical Distribution of Key Protected Wild Vascular Plants in Jiangxi Province (Postprint)

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Abstract

Rare and endangered wild plants are important strategic resources and a crucial component of biodiversity conservation. Understanding the diversity and geographic distribution of key protected plants in Jiangxi Province is a critical step in formulating scientific protection and management measures at the provincial level. By integrating the species distributed in Jiangxi Province from the *National Key Protected Wild Plants List* (2021) and the *Jiangxi Provincial Key Protected Wild Plants List* (2005), combined with digitized specimen distribution data from the National Specimen Resource Sharing Platform, we analyzed the diversity, conservation status, and geographic distribution characteristics of key protected wild vascular plants in Jiangxi Province. The results show: 1) There are 148 species (including infraspecific taxa) of national key protected plants distributed in Jiangxi Province, belonging to 47 families and 89 genera. 2) The integrated Jiangxi provincial key protected plants total 407 species, belonging to 85 families and 208 genera. Among them, lycophytes and ferns account for 16 species in 10 genera and 9 families; gymnosperms account for 26 species in 17 genera and 6 families; angiosperms account for 365 species in 181 genera and 70 families. 3) Among the 407 key protected plant species, 60.9% of the species are distributed in 32 national and provincial nature reserves; 70.5% of the species are distributed in 67 botanical gardens in China. 4) The observed and estimated values of species richness indicate that regions with higher species richness include Lushan in the north, Jiulingshan, Wugongshan, and Jinggangshan in the west, Dayuling and Jiulianshan of the Nanling Range in the south, and Wuyishan and its adjacent areas in the east. The estimated pattern of key protected plant species richness shows high consistency with the five key biodiversity conservation areas in Jiangxi Province. This paper discusses the problems existing in the species included in the *Jiangxi Provincial Key Protected Plants List* (2005), and proposes the 6E principles for priority

species selection in future provincial protected plant lists and relevant recommendations for strengthening research on provincial key protected plants.

Full Text

Preamble

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Comparative Study and Geographical Distribution of Key Protected Wild Vascular Plants in Jiangxi Province, China

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Abstract

Rare and endangered wild plants constitute important strategic resources and an essential component of biodiversity conservation. Understanding the diversity and geographic distribution of key protected plants in Jiangxi Province is a critical step toward developing scientifically sound conservation and management strategies at the provincial scale. By integrating the National Key Protected Wild Plants List (2021) for species distributed in Jiangxi with the Key Protected Wild Plants List of Jiangxi Province (2005), and incorporating digitized herbarium specimen data from the National Specimen Information Infrastructure, we analyzed the diversity, conservation status, and geographic distribution patterns of key protected wild vascular plants in Jiangxi Province. The results show: (1) A total of 148 species (including infraspecific taxa) from 89 genera and 47 families of national key protected plants are found in Jiangxi. (2) The integrated list comprises 407 species from 208 genera and 85 families, including 16 lycophyte and fern species (10 genera, 9 families), 26 gymnosperm species (17 genera, 6 families), and 365 angiosperm species (181 genera, 70 families). (3) Among these 407 species, 60.9% occur in 32 national and provincial nature reserves, while 70.5% are conserved in 67 botanical gardens across China. (4) Observed and estimated species richness values indicate that hotspots are located in Lushan in the north, Jiuling, Wugong, and Jinggang mountains in the west, Dayuling and Jiulian mountains of the Nanling range in the south, and Wuyi mountain and adjacent areas in the east. The estimated richness pattern shows strong concordance with Jiangxi's five key biodiversity conservation areas. This paper discusses issues with the species included in the 2005 Jiangxi Provincial Key Protected Plants List and proposes 6E principles for future selection of priority species for provincial protection lists, along with recommendations for strengthening research on provincial key protected plants.

Keywords: China, conservation biology, distribution pattern, Jiangxi Province,

key protected plant checklist, rare and endangered plants, species richness

Introduction

Wild plants provide essential material foundations for human survival and development, including food, vegetables, medicinal materials, timber, ornamental plants, and oxygen, forming a crucial component of Earth' s ecosystems (National Research Council, 1999; Hiscock et al., 2019; Knapp, 2019). As important strategic and genetic resources, wild plants serve as material carriers and sources of inspiration for cultural development, and their conservation represents a vital guarantee for ecological and resource security (Zhou and Jin, 2021). National and provincial key protected wild plant lists provide critical scientific foundations for conservation and management efforts. Since the 1990s, publications such as the *National Key Protected Plants List* (Fu, 1995; Yu, 1999), *China Plant Red Data Book* (Fu, 1991), and *China Species Red List* (Wang and Xie, 2004) have established important research foundations for conserving rare and endangered plants in China. The new *National Key Protected Wild Plants List* (2021), released by the National Forestry and Grassland Administration and Ministry of Agriculture and Rural Affairs (Announcement No. 15 of 2021), clarifies the species under national key protection under new circumstances, providing a basis for strengthening legal protection, combating illegal collection and excavation, and raising public awareness (Lu et al., 2021; Xu & Zang, 2023; Wu et al., 2023).

Jiangxi Province was among the first provinces to respond actively to wild plant conservation initiatives. In June 1994, it adopted the *Interim Measures for the Protection and Management of Wild Plant Resources in Jiangxi Province*, and in October of the same year, the Provincial Department of Forestry published the first batch of the *Key Protected Plants List of Jiangxi Province* comprising 163 species (Wang, 1994; Xie, 1994; Committee of the Chinese Complete Book of Agriculture, 2001). Based on the status of wild plant resource conservation and utilization, the provincial key protected list was adjusted in 2005. The revised list explicitly included three plant categories—all Orchidaceae species, *Elaeocarpus* L., and *Lagerstroemia* L. distributed in Jiangxi—plus over 120 additional species, totaling more than 300 wild plant species assigned to three protection levels according to their importance.

Previous researchers have conducted studies on key protected plants in Jiangxi based on the *National Key Protected Wild Plants List* (first batch, 1999) and various versions of the *Key Protected Wild Plants List of Jiangxi Province*. For instance, Zang and Mao (2005), Zang et al. (2007), and Wang et al. (2007) analyzed the floristic composition of 103, 53, and 87 species, respectively, while Zang et al. (2007), Yu et al. (2016), and Zang et al. (2018) examined the geographic distribution of 53, 313, and 422 species, respectively. These studies provided important references for formulating the *Jiangxi Province Biodiversity Conservation Strategy and Action Plan 2013-2030*. However, with new floristic discoveries in Jiangxi (Ji et al., 2019; Zheng et al., 2019; Liu et al., 2020;

Liu et al., 2020; Zhao et al., 2020; Qin et al., 2021; Liao et al., 2022; Xu and Huang, 2023) and the recent publication of multiple plant inventories (Peng et al., 2021; Ji et al., 2022; Wu et al., 2022), the species composition and related information for rare and endangered plants in Jiangxi have changed substantially. It has become necessary to systematically review and study the key protected wild plants in Jiangxi based on the latest *National Key Protected Wild Plants List* (2021) integrated with the 2005 provincial protection list. To date, no study has conducted a comparative analysis of the species in the *Key Protected Plants of Jiangxi Province* (2005) and the *National Key Protected Wild Plants List* (2021) for Jiangxi. Important questions remain regarding the selection of provincial key protected plants: Do national and provincial protection lists overlap? Do provincially protected species reflect priority protection principles for threatened species? Clarifying these fundamental issues will provide crucial decision-making support for future adjustments and improvements to provincial protection lists and for coordinated management of national and provincial protected plants within the province. Furthermore, studies on the geographic distribution of key protected plants provide scientific foundations for field surveys, spatial conservation planning, and decision-making (Zhang & Ma, 2008; Zhang and Ma, 2008; Yuan et al., 2009) and are fundamental to implementing effective conservation (Flather et al., 1998; Ma, 2001; Ferrier, 2002). Therefore, integrating national key protected wild plants distributed in Jiangxi, the provincial protection list, and related data to investigate the diversity and geographic distribution of key protected plants is a critical step toward developing scientific conservation and management strategies at the provincial scale.

1.1 Study Area Overview

Jiangxi Province is located in the southeastern-central part of China (113°35 -118°29 E, 24°29 -30°05 N) along the southern bank of the middle and lower Yangtze River, covering an area of approximately 170,000 km^2. The province is characterized by mountains on three sides, undulating hills in the center, and a topography that slopes from high in the south to low in the north, gradually inclining toward Poyang Lake from south to north and from the periphery inward (Figure 2 [Figure 2: see original paper]: A). The region experiences a warm and humid mid-subtropical monsoon climate, with mean annual temperatures of 16.3–19.5 °C (slightly decreasing from south to north) and mean annual precipitation of 1,350–1,940 mm. Historically, Jiangxi lies at the intersection of the Paleotropical and Holarctic floristic kingdoms. Influenced by long-term East Asian monsoonal climate with abundant water and heat (He & Wang, 2021), the region was not directly affected by significant Quaternary continental glaciation, preserving and nurturing rich plant diversity and representing one of the areas with the longest evolutionary history of subtropical flora (Lin, 1983; Jiangxi Forestry Editorial Committee, 1986; Xie, 1991). The complex and diverse mountainous terrain, together with evergreen broad-leaved forests forming a "green protective umbrella," has preserved plants that migrated southward during glacial periods and northward during interglacial periods, serving as a "refuge" for ancient ferns, gymnosperms, and primitive angiosperms and as an ideal "transitional habitat" for southward and northward migrating plants (Yang, 2018). The province hosts numerous endemic and rare endangered plant species (Xie et al., 1996; Ji et al., 2010; Zang et al., 2018) and is the most plant-diverse province in East China, with over 5,600 species of wild vascular plants (Peng et al., 2021; Xu, 2021; Ji et al., 2022; Wu et al., 2022).

1.2 Checklist and Distribution Data Integration

The integration of checklists and distribution data involved seven steps: (1) We compiled the *Inventory of Vascular Plant Diversity in Jiangxi* (Peng et al., 2021), *List of Wild Angiosperms in Jiangxi* (Wu et al., 2022), and *List of Wild Vascular Plants in Jiangxi* (2022 edition) (Ji et al., 2022), along with recently published new distribution records for Jiangxi vascular plants (Ji et al., 2019; Zheng et al., 2019; Liu et al., 2020; Liu et al., 2020; Zhao et al., 2020; Qin et al., 2021; Liao et al., 2022; Xu, 2023) to form a relatively complete checklist of wild vascular plants in Jiangxi with provincial- and county-level distribution information. (2) Based on the *National Key Protected Wild Plants List* and distribution information from step (1), we identified 148 species (including infraspecific taxa) from 89 genera and 47 families of national key protected plants distributed in Jiangxi. (3) Using the checklist and distribution information from step (1), we compiled the *Key Protected Wild Plants List of Jiangxi Province* (2005), which includes all Orchidaceae, *Elaeocarpus* L., and *Lagerstroemia* L. species distributed in Jiangxi, plus other species totaling 305 species. (4) We merged the lists from steps (2) and (3) to create a final list of 407 wild plant species (excluding introduced and cultivated species, belonging to 208 genera and 85 families) representing key protected plants in Jiangxi. (5) Based on the scientific names of the 407 species, we directly compared and matched them with 427,565 digitized vascular plant specimens from Jiangxi in the National Specimen Information Infrastructure (NSII), excluding records from outside Jiangxi. (6) We systematically examined herbarium specimens from the Lushan Botanical Garden Herbarium (LBG), Jiangxi Agricultural University Forestry College Wood Herbarium (JXAU), Jiujiang Forest Plant Herbarium (JJF), Nanchang University Biological Herbarium (JXU), and related literature to verify the identification and distribution information for some species. (7) We used the Amap geocoding web service interface (https://lbs.amap.com/api/webservice/guide/api/georegeo/) to supplement missing latitude and longitude information for distribution records, ultimately creating a distribution dataset comprising 15,065 records with latitude and longitude information for 361 key protected plant species (unique occurrence points). Taxonomic classification and nomenclature in the checklist data follow the *Catalogue of Life China (Plant Volume)* (Wang et al., 2015; Wang et al., 2018; Lu et al., 2021) to ensure consistency in data matching and the relative completeness and accuracy of the Jiangxi key protected wild plant checklist and distribution information.

1.3 Distribution in Protected Areas and Botanical Garden Cultivation Records

Based on the nature reserve catalog published by the Ministry of Ecology and Environment (http://www.mee.gov.cn) and the list of Jiangxi nature reserves in the *Jiangxi Province Biodiversity Conservation Strategy and Action Plan 2013-2030*, we created vector layers for 15 national nature reserves and 32 provincial nature reserves in Jiangxi. By overlaying specimen distribution points with nature reserve layers, we calculated the number of key protected wild plant species occurring in each reserve. Based on the *Checklist of Ex Situ Cultivated Flora of China* (Huang, 2014), *Encyclopedia of Chinese Garden Flora* (Huang, 2017), published volumes of *Ex Situ Flora of China* (Huang, 2014-2021), and *Catalogue of Cultivate Plants in China* (Lin, 2017), we identified and quantified the species and numbers of key protected plants cultivated in botanical gardens.

1.4 Spatial Distribution Estimation of Key Protected Plant Species Richness

We divided Jiangxi into 1,680 grids at a spatial resolution of 1 km × 1 km as the analysis unit. Through spatial overlay analysis of vector layers and 15,065 distribution records (for 361 species), we calculated the number of distribution points and species in each grid. The number of distribution points was log10-transformed and rasterized to map survey intensity in each grid. Using the widely adopted metric of species richness (SR) (Prendergast et al., 1993; Davies & Cadotte, 2011), we calculated the number of species in each grid as the observed species richness. We employed a Regression-Kriging (R-K) model to estimate species richness for each grid as the estimated value. The R-K model represents a spatial version of best linear unbiased estimation, modeling target variables as functions of deterministic (i.e., spatial autocorrelation) and random components (Hengl et al., 2007; Hengl, 2009; Cressie & Wikle, 2011). We used the difference between estimated and observed species richness values as an indicator of survey completeness and knowledge gaps, mapping these results spatially.

The R-K analysis first requires selecting relatively well-surveyed grids to calculate the semi-variogram. We used fitted species accumulation curves to describe the relationship between species richness and survey intensity in each grid (Lobo et al., 2018; Alves et al., 2019). We then integrated three metrics from this process: (1) completeness—the percentage of estimated species richness derived from species accumulation curves; (2) ratio—the ratio between the number of records and observed species richness in a grid; and (3) slope—the slope between observed cumulative species richness and number of distribution points. Following Sousa-Baena et al. (2014), we selected grids with completeness >85%, ratio >4, slope <0.02, and >250 records as relatively well-sampled units. These analyses were completed using the R package KnowBR (Lobo et al., 2018). We then obtained 16 environmental variables from WorldClim version

2.1 (Fick & Hijmans, 2017). Through correlation analysis using a Pearson correlation coefficient threshold of <0.7, we retained nine environmental variables: mean annual temperature, temperature seasonality, minimum temperature of the coldest month, annual temperature range, mean annual precipitation, precipitation of the driest month, precipitation seasonality, precipitation of the driest quarter, and elevation. These analyses were performed using R packages ape (Paradis et al., 2004), MuMIn (Barton, 2009), and raster (Hijmans & van Etten, 2014).

2.1 Diversity and Distribution in Protected Areas and Botanical Gardens

The integrated list of key protected wild vascular plants in Jiangxi comprises 407 species from 208 genera and 85 families. Among these, 148 species are listed in the *National Key Protected Wild Plants List* (2021) and 305 species in the *Key Protected Wild Plants List of Jiangxi Province* (2005) (Figure 1 [Figure 1: see original paper]: A). The 407 species include 16 lycophyte and fern species (10 genera, 9 families), 26 gymnosperm species (17 genera, 6 families), and 365 angiosperm species (181 genera, 70 families) (Figure 1: B–D, Appendix 1). A total of 60.7% of species (247) occur in 14 national (230 species, 56.5% of total) and 18 provincial reserves (133 species, 32.7% of total) in Jiangxi, while 70.5% (287 species) have ex situ conservation records in 67 botanical gardens across China (Figure 1: E–F, Appendix 1). The nature reserves with the highest numbers of key protected plant species are Lushan (130 species), Jinggangshan (87), Yishan (71), Jiulianshan (58), Qiyunshan (46), Guanshan (45), Matoushan (45), Yanquan (37), Wuzhifeng (35), Yangjifeng (33), Yujingshan (28), Wuyishan (27), Nanfengmian (23), and Yunjushan (20); the remaining 18 reserves have fewer than 20 species (Table S1). The botanical gardens with the most key protected plant species are Wuhan Botanical Garden, Chinese Academy of Sciences (WBG, 220 species), South China National Botanical Garden (SCBG, 205), Hangzhou Botanical Garden (HBG, 185), Nanjing Zhongshan Botanical Garden (NBG, 174), Shanghai Chenshan Botanical Garden (CBG, 160), Xishuangbanna Tropical Botanical Garden (XTBG, 160), Kunming Botanical Garden (KBG, 142), Guilin Botanical Garden (GXIB, 138), Shenzhen Fairy Lake Botanical Garden (FLBG, 135), Dongguan Botanical Garden (DGBG, 130), Gannan Arboretum (GNA, 129), Fuzhou Botanical Garden (FBG, 125), Xiamen Botanical Garden (XMBG, 122), Lushan Botanical Garden (LSBG, 121), Guizhou Botanical Garden (GBG, 106), Hunan Forest Botanical Garden (HNFBG, 105), and Zhejiang A&F University Botanical Garden (ZAFU, 105); other botanical gardens have fewer than 100 species (Table S2).

Comparisons reveal that 46 species overlap between the national key protected plants and the 2005 provincial protection list (Figure 1: A). Among the 259 provincial key protected species (excluding the 46 overlapping species), only 18.5% are threatened, including 7 Critically Endangered (CR), 10 Endangered (EN), and 31 Vulnerable (VU) species. A substantial 63.7% (165 species) are

Least Concern (LC), 13.5% (35 species) are Near Threatened (NT), and 2.3% (6 species) lack assessment data (Figure 1: G). Of the 259 species, 68 (26.3%) are endemic to China, with 60.3% of these endemics (41 species) classified as LC and only 14 species threatened (3 CR, 1 EN, and 10 VU) (Figure 1: H).

2.2 Spatial Distribution Patterns of Species Richness

Species with unique latitude-longitude distribution points (361 species) account for 88.7% of the total key protected plants in Jiangxi (407 species). Distribution patterns show that 17.2% of species (62) have only one occurrence point, 15.2% (55) have 2-5 points, 11.1% (40) have 6–10 points, 19.4% (70) have 11–30 points, 11.9% (43) have 31–50 points, 13.3% (48) have 51–100 points, and 11.9% (43) have more than 100 points. Species with over 300 distribution points include *Loropetalum chinense* (419 points), *Syzygium buxifolium* (349), *Cephalotaxus fortunei* (332), and *Ilex rotunda* (331). High survey intensity grids are concentrated in mountainous areas of northwestern, western, southern, and eastern Jiangxi, particularly in Lushan and Jinggangshan (Figure 2: C). Although survey intensity varies significantly among grids, overall, survey sites cover the entire geographic and environmental gradient of Jiangxi (Figure 2: A–C). Grids with observed species richness $ $20 are mainly distributed in mountainous areas surrounding Jiangxi, especially Lushan in the north, Jiuling, Wugong, and Jinggang mountains in the west, Dayuling and Jiulianshan in the south, and Wuyishan and adjacent areas in the east (Figure 2: D). R-K analysis estimated species richness $ $50 in five relatively continuous regions from north to south: (1) the Huaiyu and Sanqingshan mountains and adjacent areas in northeastern Jiangxi; (2) the Poyang Lake basin, including Lushan and Poyang Lake National Nature Reserve and adjacent areas; (3) the northern Wuyi mountain range, including areas adjacent to Wuyishan and Matoushan National Nature Reserves; (4) the Luoxiao Mountains in western Jiangxi, including Jiulingshan, Guanshan, Wugongshan, and Jinggangshan and adjacent areas; and (5) the Nanling Mountains in southern Jiangxi, including Dayuling, Jiulianshan, Luanluofeng, and Xiangshanzeng (Figure 2: E). Regions with continuous high estimated species richness also show relatively higher field survey gaps (Figure 2: F).

3.1 Revision of the Provincial Key Protected Plants List

A protection list represents a collection of protected species (Jiang, 2019), and the selection and revision of key protected species lists constitute the fundamental basis for effectively implementing wild plant conservation and enforcing the *Regulations of the People' s Republic of China on the Protection of Wild Plants* (https://www.forestry.gov.cn/main/3950/20170314/459881.html) and the *Interim Measures for the Protection and Management of Wild Plant Resources in Jiangxi Province* (http://www.jiangxi.gov.cn/attach/0/b7c6e571449b4a22b513d253c740cbac.pdf). These legal instruments not only enable crackdowns on illegal collection, excavation, and trade but also guide conservation efforts (Lu et al., 2021; Wu et al., 2023). The *Regulations* clearly stipulate that wild plants are classified as nationally or locally key protected, with national protection further divided into first-class and second-class categories. The national list is formulated by State Council forestry and agricultural authorities in consultation with environmental protection and construction departments and approved by the State Council. Provincial key protected wild plants refer to those not nationally protected but protected by provincial governments, with lists formulated and published by provincial governments and filed with the State Council. Jiangxi Provincial Government Order No. 241 (fourth amendment, September 2019) specifies list-based management for provincial key protected wild plants. Therefore, the *National Key Protected Wild Plants List* (2021) and the *Key Protected Wild Plants List of Jiangxi Province* (2005) currently represent the most important scientific foundations for conserving rare and endangered plants in Jiangxi. These two lists form a hierarchical protection and management system from central to local levels, serving as crucial references for natural resources, forestry law enforcement, customs inspection, and related departments at all local levels.

Our study reveals that the current *Key Protected Wild Plants List of Jiangxi Province* (2005) requires substantial revision and improvement. For example, similar to issues with Jiangxi' s animal protection list (Jiang, 2019), 46 species overlap between the national and provincial key protected plant lists and should be excluded from future provincial lists. Among the 259 provincial key protected species (excluding overlaps), a striking 77.2%—including 63.7% LC species (165) and 13.5% NT species (35)—are assessed as not seriously threatened, while only 18.5% (48 species) are threatened. Only 26.3% (68 species) are endemic to China, and most of these endemics (60%) are LC species. These figures indicate that the current provincial list does not prioritize threatened species distributed in Jiangxi, such as *Psilotum nudum* (VU), *Dryopteris whangshangensis* (EN), *Quercus chungii* (EN), *Rhododendron xiaoxidongense* (EN), and *Mazus danxiacola* (CR). Additionally, Jiangxi has rich wetland ecosystems with over 580 wetland plant species (He et al., 2015), yet the provincial list contains no representative aquatic plants (six aquatic species are included in the national list). Systematic assessment and inclusion of aquatic plants in provincial protection targets should be a priority for future list updates.

Moreover, past selection of provincial key protected plants relied primarily on expert group decisions without clear principles and criteria, inevitably affecting the comprehensiveness and representativeness of protection lists. To fully embody scientifically sound decision-making processes based on the "protection priority principle" (Mace et al., 2007; Brown et al., 2015; Carwardine et al., 2018; Le Berre et al., 2019; Hernandez et al., 2022), we propose 6E reference principles for inclusion in provincial protection lists: (1) **Endangerment**—selecting threatened taxa most in need of ex situ conservation; (2) **Endemism**—selecting threatened taxa representative of local or regional endemism; (3) **Economic**—selecting taxa providing local or regional economic or social resources, such as medicinal plants; (4) **Ecological**—selecting taxa that maintain ecological processes or support habitat restoration; (5) **Emblematic**—selecting threatened taxa that can serve as flagship species for landscape and habitat conservation; and (6) **Evolutionary**—representing evolutionarily significant and unique units. The first five E principles derive from Maunder et al.' s (2004) 5E criteria for prioritizing rare and endangered plants for ex situ conservation, while the sixth E principle reflects the importance of phylogenetic diversity in biodiversity conservation prioritization (Faith, 1992; Sarkar et al., 2006; Isaac et al., 2007; Faith, 2008). Applying these principles will help clarify the relationship between national and provincial protection lists, creating a clear protection hierarchy from national to provincial levels that facilitates implementation, management, identification of protection targets, and law enforcement. These 6E principles align with the five basic principles for the *National Key Protected Wild Plants List* (Lu et al., 2021) and are equally applicable for selecting provincial protection targets.

3.2 Spatial Distribution of Species Richness of Key Protected Plants

The R-K analysis results show high consistency with empirical observations. For example, floristic surveys have identified 196 rare and endangered species (including 25 nationally protected) in Matoushan (Bao et al., 2016), 57 national key protected wild plant species in Wugongshan (Zhou et al., 2023), 182 rare and endangered species (including national and provincial key protected) in Fenyi County (Zhong et al., 2019), and 63 species in Yichun City (Wang et al., 2023), with 58 rare and endangered species in Lushan (Wan et al., 2019). All these regions correspond to high-value areas in the R-K model estimates. Additionally, the high-value areas identified by R-K analysis—including Jiulianshan in the Nanling range, and Matoushan and Yangjifeng in the Wuyi range and adjacent areas—are also priority regions in Jiangxi' s nature reserve development plan (Huang et al., 2014). Overall, the continuous high-value regions estimated by R-K analysis align well with Jiangxi' s five key biodiversity conservation areas: (1) the eastern Wuyi-Huaiyu mountains subtropical high-elevation broad-leaved and mixed forest biodiversity key area; (2) the southern Nanling-Jiulian mountains mid-south subtropical evergreen broad-leaved forest biodiversity key area; (3) the western Luoxiao mountains subtropical high-elevation evergreen broad-leaved and mixed forest biodiversity key area; (4) the northwestern Mufu-Jiuling mountains mid-north subtropical evergreen deciduous broad-leaved mixed forest key area; and (5) the Poyang Lake wetland and inter-river biodiversity key area. The R-K analysis also provides guidance for future field surveys, revealing knowledge gaps in both high- and low-survey-intensity regions that warrant focused attention. However, R-K analysis is subject to inherent biases in survey data; for instance, survey intensity in Lushan, Jiulingshan, Wugongshan, and Jinggangshan and adjacent areas is significantly higher than elsewhere, resulting in relatively higher observed and estimated species richness. Detailed geographic distribution knowledge is often incomplete and biased (Lomolino, 2004; Yang et al., 2013; Hortal et al., 2015), causing many diversity distribution maps to reflect survey data distribution rather than true diversity patterns

(Hortal et al., 2007). Comprehensive species distribution knowledge depends on the temporal and spatial intensity of field surveys and associated socioeconomic factors (Hortal et al., 2008; Boakes et al., 2010; Yang et al., 2014). Therefore, field surveys of key protected plant distributions remain a long-term research endeavor. Overall, the distribution point data used in our R-K model analysis covered the entire geographic and environmental gradient of Jiangxi, enabling effective estimation of species richness distribution patterns that can positively guide spatial conservation planning for key protected plants.

Compared to methods using species distribution ranges such as extent of occurrence (EOO) and area of occupancy (AOO) (Gaston & Fuller, 2009; IUCN, 2020) and ecological niche modeling (SDM) (Franklin & Miller, 2010; Peterson et al., 2011), the R-K method offers the advantage of utilizing the dual spatial autocorrelation of species richness and environmental variables to construct continuous species richness gradients across the study area based on relatively few survey samples (provided samples are well-represented across geographic and environmental gradients) (Alves et al., 2019). For rare and endangered plants with very narrow distributions, geographic and environmental sampling bias is particularly severe (Gaston, 1997; Gaston, 2003), often distorting true species richness patterns in analyses based on distribution ranges and SDM (Gaston & Fuller, 2009; Pineda & Lobo, 2012). The R-K model provides statistical estimation of species richness geographic gradients to guide future species surveys, conservation decisions, and inference of environmental change impacts (Alves et al., 2019).

3.3 Future Research and Conservation Strategies for Key Protected Plants

The ambitious "30$×$30" target of the Kunming-Montreal Global Biodiversity Framework reflects urgent global aspirations to reverse biodiversity loss (Ma, 2023; Xu and Wang, 2023; Ping et al., 2023) and sets higher requirements for conserving rare and endangered plants. Effective conservation of rare and endangered plants is a long-term and arduous task requiring comprehensive understanding of species' biological characteristics, geographic distribution, responses and adaptations to climate change, population genetic diversity, and threat factors to effectively guide conservation, restoration, and reintroduction practices (Heywood, 2017). In conservation management and decision-making, we often face the dilemma of "insufficient information" or even "information gaps," while substantial information may be scattered across various research publications and even news reports. Therefore, constructing databases and analytical decision-making platforms covering species' geographic distributions, population dynamics, and genetic diversity using modern information technology will provide data and information support for the "one species, one strategy" approach (Huang and Liao, 2022). For example, using molecular biology techniques to construct DNA barcode and genome libraries for endangered species to preserve complete genetic information will provide ultimate safeguards for species conservation (Yu et al., 2013; Wei et al., 2022). Meanwhile, comprehensive application of various conservation biology tools, including ex situ conservation, in situ conservation, reintroduction, and population recovery, has become an important consensus in conservation biology research to ensure effective conservation outcomes (Falk, 1990; Newton & Oldfield, 2012; Fišer et al., 2021; Yang et al., 2022; Borzée & Button, 2023).

Among the 407 key protected plant species in Jiangxi, 60.9% (248 species) have distribution records in 32 nature reserves, primarily concentrated in national and provincial reserves such as Lushan in the north and Jinggangshan, Yishan, and Jiulianshan in the west. Additionally, 70.5% (287 species) have cultivation records in 67 botanical gardens across China. Although these statistics cannot accurately measure actual in situ and ex situ conservation status, they provide important references for integrated conservation of provincial key protected plants by nature reserves and botanical gardens. While in situ conservation based on protected areas remains the most direct and effective approach for rare and endangered plants (Jiang et al., 2023), the advantages and roles of botanical gardens in ex situ and integrated conservation should not be overlooked (Heywood, 2015). For example, *Cymbidium kanran* is widely distributed in Jiangxi' s mountainous environments, but its populations and distribution have declined sharply due to over-collection, habitat fragmentation, and loss (Yang, 2017). Achieving in situ conservation across its entire range is unrealistic, making ex situ conservation (e.g., cultivation and propagation) potentially the most direct and effective method.

Jiangxi has established over 190 nature reserves of various types, along with several ex situ conservation institutions and facilities such as Lushan Botanical Garden and Gannan Arboretum, providing important support platforms for integrated conservation of rare and endangered plants. However, most national and provincial nature reserves are concentrated around mountains as isolated islands with relatively small areas, constrained by administrative boundaries and lacking effective connectivity (Liu, 1994; Huang et al., 2014), resulting in a "fragmented" in situ conservation network. Furthermore, systematic coordination between reserves and botanical gardens is lacking. Coinciding with China' s development of national park and national botanical garden systems (Ouyang et al., 2021; Yang, 2021; Huang and Liao, 2022; Wen et al., 2023), Jiangxi's rich key protected wild plants present both opportunities and challenges for provincial plant diversity conservation. To strengthen integrated conservation of rare and endangered plants within the province, we propose three recommendations: (1) Continue strengthening basic research on resource surveys, Red List assessments, and genetic diversity; (2) Establish a provincial big data platform for rare and endangered plants as soon as possible to promote data integration and improve scientific decision-making for conservation management; and (3) Enhance coordination and linkage between in situ and ex situ conservation institutions under an integrated conservation framework to improve comprehensive conservation capacity and achieve synergistic conservation benefits.

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References

ALVES DMCC, EDUARDO AA, DA SILVA OLIVEIRA EV, et al., 2019. Unveiling geographical gradients of species richness from scant occurrence data[J]. Glob Ecol Biogeogr, 29(4): 748-759.

BARTON K, 2009. MuMIn: multi-model inference. R package version 1.0.0. http://r-forge.r-project.org/projects/mumin/.

BAO ZG, LI JX, GE G, et al., 2016. Rare and endangered plants in Jiangxi Matoushan national nature reserve[J]. J Nanchang Univ (Nat Sci), 40(5): 497-505.

BOAKES EH, MCGOWAN PJK, FULLER RA, et al., 2010. Distorted views of biodiversity: spatial and temporal bias in species occurrence data[J]. PLoS Biol, 8(6): 1-11.

BORZÉE A, BUTTON S, 2023. Integrative conservation science: conservation knowledge must be used to guide policies[J]. Integrat Conserv, 2(2): 69-72.

BROWN CJ, BODE M, VENTER O, et al., 2015. Effective conservation requires clear objectives and prioritizing actions, not places or species[J]. Proc Nat Acad Sci, 112(32): E4342-E4342.

CARWARDINE J, MARTIN TG, FIRN J, et al., 2018. Priority threat management for biodiversity conservation: a handbook[J]. J Appl Ecol, 56(2): 481-490.

CRESSIE N, WIKLE CK, 2011. Statistics for spatio-temporal data[M]. Hoboken, New Jersey: Wiley: 1-624.

DAVIES TJ, CADOTTE MW, 2011. Quantifying biodiversity, does it matter what we measure?[M]// ZACHOS FE, Habel JC. Biodiversity hotspots: distribution and protection of conservation priority areas. New York: Springer: 43-60.

FAITH DP, 1992. Conservation evaluation and phylogenetic diversity[J]. Biol Conserv, 61(1): 1-10.

FAITH DP, 2008. Threatened species and the potential loss of phylogenetic diversity: conservation scenarios based on estimated extinction probabilities and phylogenetic risk analysis[J]. Conserv Biol, 22(6): 1461-1470.

FALK DA, 1990. Integrated strategies for conserving plant genetic diversity[J]. Ann Mo Bot Gard, 77(1): 38-47.

FERRIER S, 2002. Mapping spatial pattern in biodiversity for regional conservation planning: where to from here?[J]. Syst Biol, 51(2): 331-363.

FICK SE, HIJMANS RJ, 2017. WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas[J]. Int J Climatol, 37(12): 4302-4315.

FIŠER Ţ, ARONNE G, AAVIK T, et al., 2021. ConservePlants: an integrated approach to conservation of threatened plants for the 21st century[J]. Res Idea Outcomes, 7: e62810.

FLATHER C, KNOWLES M, KENDALL I, 1998. Threatened and endangered species geography[J]. Biosci, 48(5): 365-376.

FRANKLIN J, MILLER JA, 2010. Mapping species distributions spatial inference and prediction[M]. Cambridge: Cambridge University Press: 1-320.

FU LG, 1991. China plant red data book[M]. Beijing: Science Press: 1-736.

FU LG, 1995. The gospel of China' s rare and endangered plants——The list of national key protected wild plants to be published soon[J]. Life World, (3): 2-3.

GASTON KJ, 2003. The structure and dynamics of geographic ranges[M]. New York: Oxford University Press: 1-280.

GASTON KJ, KUNIN, W. E, 1997. Rare-common differences: an overview. [M]// KUNIN WE, GASTON KJ. The biology of rarity: causes and consequences of rare-common difference. London: Chapman & Hall: 12-29.

GASTON KJ, FULLER RA, 2009. The sizes of species' geographic ranges[J]. J Appl Ecol, 46(1): 1-9.

HE M, ZHENG YT, YAN YY, et al., 2015. Current status and conservation and utilisation of wetland plant resources in Jiangxi Province[J]. Jiangsu Agric Sci, 43(9): 412-417.

HE WL, WANG XJ, 2021. A miocene flora from the toupi formation in Jiangxi Province, southeastern China[J]. Palaeoworld, 30(4): 757-769.

HENGL T, 2009. A practical guide to geostatistical mapping[M]. BPR Publishers.

HENGL T, HEUVELINK GBM, ROSSITER DG, 2007. About regression-kriging: from equations to case studies[J]. Comput Geosci, 33(10): 1301-1315.

HERNANDEZ JO, BUOT IE, PARK BB, 2022. Prioritizing choices in the conservation of flora and fauna[J]. Res Trend Method App, 11(10): 1645.

HEYWOOD VH, IRIONDO JM, 2003. Plant conservation: old problems, new perspectives[J]. Biol Conserv, 113(3): 321-335.

HEYWOOD VH, 2015. In situ conservation of plant species –an unattainable goal?[J]. Israel J Plant Sci, 63(4): 211-231.

HEYWOOD VH, 2017. Plant conservation in the anthropocene –challenges and future prospects[J]. Plant Divers, 39(6): 314-330.

HIJMANS RJ, VAN ETTEN J, 2014. raster: Geographic data analysis and modeling. R package version 2.8.

HISCOCK SJ, WILKIN P, LENNON S, et al., 2019. Plants matter: introducing plants, people, planet[J]. Plants, People, Planet, 1(1): 2-4.

HORTAL J, DE BELLO F, DINIZ-FILHO JAF, et al., 2015. Seven shortfalls that beset large-scale knowledge of biodiversity[J]. Annu Rev Ecol Evol Syst, 46(1): 523-549.

HORTAL J, JIMÉNEZ-VALVERDE A, GÓMEZ JF, et al., 2008. Historical bias in biodiversity inventories affects the observed environmental niche of the species[J]. Oikos, 117(6): 847-858.

HORTAL JN, LOBO JM, JIMÉNEZ-VALVERDE A, 2007. Limitations of biodiversity databases: case study on seed-plant diversity in tenerife, canary islands[J]. Conserv Biol, 21(3): 853-863.

HUANG HW, 2014. A checklist of ex situ cultivated flora of China[M]. Beijing: Science Press.

HUANG HW, 2014-2021. Ex situ flora of China (Vol.1-22)[M]. Beijing: Science Press.

HUANG HW, 2017. Encyclopedia of chinese garden flora[M]. Beijing: Science Press.

HUANG HW, LIAO JP, 2022. On China's national botanical gardens: Building a comprehensive system of ex situ conservation of national botanical gardens with task oriented disciplines[J]. Biodivers Sci, 30(6): 1-17.

HUANG ZQ, LU L, DAI NH, et al., 2014. Vacancy analysis on the development of nature reserves in Jiangxi Province[J]. Acta Ecol Sin, 34(11): 3099-3106.

ISAAC NJB, TURVEY ST, COLLEN B, et al., 2007. Mammals on the EDGE: Conservation priorities based on threat and phylogeny[J]. PLoS ONE, 2(3): e296.

IUCN, 2020. Guidelines for using the IUCN red list categories and criteria version 15.1. https://www.iucnredlist.org/resources/redlistguidelines.

JI HL, ZHAN XH, ZHANG L, et al., 2019. Diversity and biogeographical characteristics of lycophytes and ferns in Mufu Mountains, China[J]. Biodivers Sci, 27(11): 1251-1259.

JI CF, QIAN P, YANG QP, et al., 2010. Research on the floristic characteristics, geographical distributions and life-forms of plants endemic to Jiangxi

Province[J]. J Wuhan Bot Res, 28(2): 153-160.

JI L, XIE YF, LI ZY, et al., 2022. A checklist of wild vascular plants in Jiangxi Province, China[J]. Biodivers Sci, 30(6): 1-8.

JIANGXI FORESTRY EDITORIAL COMMITTEE, 1986. Jiangxi Forestry[M]. Nanchang: Jiangxi Science and Technology Press.

JIANG YF, TIAN J, LIU ZL, et al., 2023. The Resource Status and Conservation Strategies of National Key Protected Wild Plants in China[J]. Forest Resour Manage, (4): 1-10.

JIANG ZG, 2019. China' s key protected species lists, their criteria and management[J]. Biodivers Sci, 27(6): 698-703.

KNAPP S, 2019. People and plants: The unbreakable bond[J]. Plants, People, Planet, 1(1): 20-26.

LE BERRE M, NOBLE V, PIRES M, et al., 2019. How to hierarchise species to determine priorities for conservation action? A critical analysis[J]. Biodivers Conserv, 28(12): 3051-3071.

LIAO HH, JIN JY, XIE YF, et al., 2022. New record species of seed plants from Jiangxi Province, China[J]. S China For Sci, 50(3): 52-53.

LIN QW, 2017. Catalogue of cultivate plants in China[M]. Beijing: Science Press.

LIN Y, 1983. The geographical distribution of forests in Jiangxi Province[J]. J Nanchang Univ (Nat Sci), (4): 1-18.

LIU H, WANG CW, XIAO HW, et al., 2020. Additional records of Orchidaceae in Jiangxi Province[J]. J Nanchang Univ (Nat Sci), 44(2): 167-171.

LIU XZ, 1994. On the developmental program for Jiangxi Province nature reserve[J]. Jiangxi Sci, (4): 248-254.

LIU ZC, ZHANG Z, LAN Y, et al., 2020. Status and management strategy for rare and endangered key protected wild plants in the Luoxiao Mountains[J]. Biodivers Sci, 28(7): 867-875.

LOBO JM, HORTAL J, YELA JL, et al., 2018. KnowBR: An application to map the geographical variation of survey effort and identify well-surveyed areas from biodiversity databases[J]. Ecol Indic, 91: 241-248.

LOMOLINO MV, 2004. Conservation biogeography[M]// LOMOLINO MV, HEANEY LR. Frontiers of biogeography: New directions in the geography of nature. Sunderland, MA: Sinauer: 293-296.

LU ZL, QIN HN, JIN XH, et al., 2021. On the necessity, principle, and process of updating the list of national key protected wild plants[J]. Biodivers Sci, 29(12): 1577-1582.

MACE GM, POSSINGHAM HP, NIGEL L-W, 2007. Prioritizing choices in conservation[M]// MACDONALD D, SERVICE K. Key topics in conservation biology 2. New Jersey: Wiley-Blackwell: 17-34.

MA KP, 2001. Hotspots assessment and conservation priorities identification of biodiversity in china should be emphasized[J]. Chin J Plant Ecol, 25(1): 125+124.

MA K P, 2023. Kunming-Montreal Global Biodiversity Framework: An important global agenda for biodiversity conservation[J]. Biodivers Sci, 31(4): 1-2.

MAUNDER M, GUERRANT E, HAVENS K, et al., 2004. Realizing the full potential of ex situ contributions to global plant conservation[M]// GUERRANT JR. E, O., HAVENS K, MAUNDER M. Ex situ plant conservation: supporting species survival in the wild. Washington (DC): Island Press: 389-418.

NATIONAL RESEARCH COUNCIL, 1999. Perspectives on biodiversity: Valuing its role in an everchanging world[M]. Washington (DC): National Academies Press: 1-153.

NEWTON A, OLDFIELD S, 2012. Integrated conservation of tree species by botanic gardens: a reference manual[M]. Richmond, UK.: Botanic Gardens Conservation International: 1-54.

OUYANG ZY, XU WH, ZANG ZH, 2021. Suggestions on improving the management system of national parks[J]. Biodivers Sci, 29(3): 272-274.

PARADIS E, CLAUDE J, STRIMMER K, 2004. APE: Analyses of phylogenetics and evolution in R language[J]. Bioinformatics, 20(2): 289-290.

PENG YS, TANG ZB, XIE YF, 2021. Inventory of species diversity of Jiangxi vascular plants[M]. Beijing: China Forestry Publishing House: 1-432.

PETERSON AT, SOBERÓN J, PEARSON RG, et al., 2011. Ecological niches and geographic distributions[M]. Princeton, New Jersey: Princeton University Press: 1-328.

PINEDA E, LOBO JM, 2012. The performance of range maps and species distribution models representing the geographic variation of species richness at different resolutions[J]. Global Ecol Biogeogr, 21(9): 935-944.

PING XG, ZHU J, WEI FW, 2023. From Egypt to Kunming-Montreal—The shift of the post-2020 global biodiversity framework[J]. Acta Theriol Sin, 43(4): 357-363.

PRENDERGAST JR, WOOD SN, LAWTON JH, et al., 1993. Correcting for variation in recording effort in analyses of diversity hotspots[J]. Biodivers Lett, 1(2): 39-53.

QIN QM, WU LF, YE HG, et al., 2021. Spermatophyte flora of Jiuling Range, Jiangxi[J]. Guihaia, 41(3): 470-481.

SARKAR S, PRESSEY RL, FAITH DP, et al., 2006. Biodiversity conservation planning tools: present status and challenges for the future[J]. Annu Rev Env Resour, 31(1): 123-159.

SOUSA-BAENA MS, GARCIA LC, PETERSON AT, 2014. Completeness of digital accessible knowledge of the plants of Brazil and priorities for survey and inventory[J]. Divers Distrib, 20(4): 369-381.

WAN JW, XIA HL, ZHOU SX, et al., 2019. Quantitative study on conservation priority of rare and endangered plants in Lushan National Nature Reserve, Jiangxi[J]. J Trop Subtrop Bot, 27(2): 171-180.

WANG S, XIE Y, 2004. China species red list, vol. 1 red list[M]. Beijing: Science Press.

WANG CX, XIAO YA, LI Y, et al., 2007. Floristic characteristics of the rare and endangered plants in Jiangxi Province[J]. J Southwest Univ (Nat Sci Ed), 29(10): 92-96.

WANG F, HUANG P, HOU DL, et al., 2023. Present situation and protection countermeasures of national key protected plants in Yichun City[J]. S China For Sci, 51(4): 41-46.

WANG JL, 1994. Overview of rare and endangered plants and nature reserves in Jiangxi Province[J]. Life World, (4): 16.

WANG LS, JIA Y, ZHANG XC, et al., 2015. Overview of higher plant diversity in China[J]. Biodivers Sci, 23(2): 217-224.

WANG LS, JIA Y, ZHANG XC, et al., 2018. Species catalogue of China: Volume 1, plants a synoptic checklist[M]. Beijing: Science Press.

WEI FW, HUANG GP, GUAN DF, et al., 2022. Digital Noah' s Ark: last chance to save the endangered species[J]. Sci China-Life Sci, 65(11): 2325-2327.

WEN SF, ZHOU ZH, HE T, et al., 2023. Background, procedures, ideas and key considerations for formulating the National Botanical Garden System Layout Plan of China[J]. Biodivers Sci, 31(9): 1-6.

WU D, LI B, YANG B, 2022. List of wild angiosperms in Jiangxi Province[M]. Beijing: China Forestry Publishing House.

WU XJ, CHEN JF, CUI GF, 2023. Proposals for updating the List of National Key Protected Wild Plants—Based on an analysis of existing conservation lists[J]. Biodivers Sci, 31(7): 1-12.

XIE GW, 1991. Studies on the woody floristic components and characters of Jiangxi[J]. Bull Bot Res, 11(1): 91-99.

XIE GW, 1994. A study on the resources of rare and endangered plants and their protection in Jiangxi Province[J]. Resour Dev Mark, 10(1): 17-19.

XIE GW, ZHOU ZD, NONG ZL, 1996. Studies on the biodiversity and protection of endenmic genera of Chinese seed plants in Jiangxi Province[J]. J Wuhan Bot Res, 14(4): 294-300.

XU CJ, 2021. Analysis of angiosperm flora in Jiangxi Province[D]. Nanchang: Jiangxi Agricultural University.

XU GL, HUANG Z, 2023. New data of vascular flora in Jiangxi Province, China[J]. J Nanjing For Univ (Nat Sci Ed), 47(3): 97-102.

XU J, WANG JZ, 2023. Analysis of the main elements and implications of the Kunming-Montreal Global Biodiversity Framework[J]. Biodivers Sci, 31(4): 1-9.

XU Y, ZANG RG, 2023. Conservation of rare and endangered plant species in China[J]. iScience, 26(2): 106008.

YANG GY, 2018. Broad-leaved evergreen forests in Jiangxi[J]. For Humankind, 341(11): 16-17.

YANG JQ, 2017. Distribution and conservation status of wild *Cymbidium kansan* Makino in Jiangxi Province[J]. S Chin Agric, 11(27): 40-41.

YANG J, TAO LD, YANG JR, et al., 2022. Integrated conservation of *Acer yangbiense*: A case study for conservation methods of plant species with extremely small populations[J]. Plants, People, Planet, 5(4): 574-580.

YANG R, 2021. National park governance system of China: Principles, vision and approaches[J]. Biodivers Sci, 29(3): 269-271.

YANG WJ, MA KP, HOLGER K, 2013. Geographical sampling bias in a large distributional database and its effects on species richness–environment models[J]. J Biogeogr, 40(8): 1415-1426.

YANG WJ, MA KP, KREFT H, 2014. Environmental and socio-economic factors shaping the geography of floristic collections in China[J]. Global Ecol Biogeogr, 23(11): 1284-1292.

YU Q, WANG SQ, JIE ZP, et al., 2016. Distribution pattern and hot spots of key-protected wild plants in Jiangxi Province[J]. S China For Sci, 44(4): 1-4.

YU WB, WANG YH, WANG H, 2013. Progress of iFlora in China: Building a Rapid Identification System for China' s National Protected Key Wild Plants[J]. Plant Divers Resour, 35(6): 706+810.

YU YF, 1999. A milestone in china' s wild plant conservation——The list of wild plants under state key protection (the first batch) [J]. Life World, (5): 3.

YUAN H, ZHANG YB, QIN HN, et al., 2009. The in situ conservation of state key protected wild plants in national nature reserves in China[J]. Biodivers Sci, 17(3): 280-287.

ZANG M, ZENG H, YU CY, et al., 2018. The geographic distribution differences of rare and endangered plants in Jiangxi Province[J]. J Fujian For Sci

Technol, 45(3): 5-12.

ZANG M, HUANG LF, LI DY, et al., 2007. Space-time analysis on the national protected wild plants in Jiangxi Province[J]. Guihaia, 27(1): 77-83.

ZANG M, MAO SJ, 2005. A analysis on the threatened protective plants in Jiangxi Province[J]. J Shangrao Norm Univer, 25(6): 90-97.

ZHANG YB, MA KP, 2008. Geographic distribution characteristics of the national key protected wild plants in Chian[J]. Chin J Appl Ecol, 19(8): 1670-1675.

ZHANG YB, MA KP, 2008. Geographic distribution patterns and status assessment of threatened plants in China[J]. Biodivers Conserv, 17(7): 1783-1798.

ZHAO WY, LIU ZC, YE HG, et al., 2020. Floristic characteristics and north-south differentiation of seed plants in the Luoxiao Mountains[J]. Biodivers Sci, 28(7): 842-853.

ZHENG SS, WANG CX, CHEN BP, et al., 2019. *Lysimachia petelotii* Merrill (Primulaceae), a newly recorded species from Jiangxi[J]. Jiangxi Sci, 37(6): 860-861.

COMMITTEE OF THE CHINESE COMPLETE BOOK OF AGRICULTURE, 2001. China agriculture book (Jiangxi volume)[M]. Beijing: China Agriculture Press.

ZHONG WH, CAO L, DU XL, et al., 2019. Study on analysis and protection tactics of rare and endangered plants in Fenyi County[J]. J Jiangxi Univ Chin Med, 31(1): 10-15.

ZHOU DZ, QIU XD, WANG SJ, et al., 2023. Analysis of floristic characteristics of key protected plants in Wugong Mountain[J]. S China For Sci, 51(3): 51-55.

ZHOU ZH, JIN XH, 2021. Analysis and suggestions on policies and regulations on conservation and management of wild plants in China[J]. Biodivers Sci, 29(12): 1583-1590.