

Postprint: Threatened Vascular Plant Species Diversity and Conservation Gaps in Tajikistan

Authors: Li Yufan, Li Wenjun, Masuliya, Su Yuqi, Wang Hongfeng

Date: 2025-02-27T00:00:00+00:00

Abstract

Threatened species are priority targets for biodiversity conservation. To understand the diversity of threatened species in Tajikistan and their conservation status, based on assessment data from the International Union for Conservation of Nature (IUCN) and Tajikistan's national Red List, the diversity of threatened vascular plant species in Tajikistan was compiled, differences between global IUCN and national Red List assessments were compared, and a conservation gap analysis for threatened plants in Tajikistan was conducted using Geographic Information System (GIS) layer overlay methods and gap analysis (GAP analysis), combined with distribution pattern maps of threatened plant richness in Tajikistan and Tajikistan protected area layers. The results show: (1) The genera with the highest number of threatened plant species in Tajikistan are *Allium*, *Tulipa*, and *Ferula*, which are significantly adversely affected primarily by grazing, collection, and mining activities. (2) The 2015 edition of the "Tajikistan Red List" [NRL (2015)] and the 2022 third edition IUCN Red List data [IUCN-RL (2022)] contain a total of 228 threatened species, with 11 species included in both lists. Among these, 6 species have a higher threat level in IUCN-RL (2022) than in NRL (2015), 4 have a lower level, and only 1 has the same level. The main reasons for this discrepancy are inconsistent assessment scales, divergent taxonomic viewpoints, substantive changes in species status, and incomplete assessment data. (3) The distribution of threatened species across various geographic regions of Tajikistan is relatively dispersed. The region with the highest threatened species richness is Hissar-Darvasian A. (4) Protected areas in Tajikistan cover only approximately 22% of the region's territory, and the boundaries of protected areas do not fully overlap with areas of high threatened species richness. Protection of key areas is insufficient and requires strengthening.

Full Text

ARID LAND GEOGRAPHY Vol. 48 No. 1 Jan. 2025

Diversity and Conservation Gaps of Threatened Vascular Plant Species in Tajikistan

LI Yufan^{1,2}, LI Wenjun^{2,3}, MA Suliya^{3,4}, SU Yuqi^{1,2}, WANG Hongfeng¹

¹ Northeast Forestry University, Harbin, Heilongjiang, China

² Key Laboratory of Conservation and Utilization of Plant Gene Resources, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi, Xinjiang, China

³ China-Tajikistan Belt and Road Joint Laboratory on Biodiversity Conservation and Sustainable Use, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi, Xinjiang, China

⁴ Inner Mongolia University of Technology, Hohhot, Inner Mongolia, China

Abstract

Threatened species are critical targets for biodiversity conservation. This study evaluates the diversity and conservation status of threatened vascular plant species in Tajikistan using data from the International Union for Conservation of Nature (IUCN) red list and Tajikistan's national red list. Discrepancies between the IUCN red list and the national red list are analyzed. Geographic information systems (GIS) and gap analysis (GAP), combined with distribution patterns of threatened plant species and the national protected area map in Tajikistan, are used to conduct a protection gap analysis for these species. The findings are as follows: (1) The genera with the highest number of threatened species in Tajikistan include *Allium*, *Tulipa*, and *Ferula*, primarily impacted by grazing, collection, and mining activities. (2) A total of 228 threatened species are recorded in both the 2015 Tajikistan red list [NRL (2015)] and the third edition of the 2022 IUCN red list [IUCN-RL (2022)], with 11 species common to both lists. In the IUCN-RL (2022), six species are classified at a higher threat level than in the NRL (2015), four at a lower threat level, and one at the same level. These discrepancies arise from differences in assessment criteria, classification perspectives, changes in species status, and incomplete data. (3) The distribution of threatened species across Tajikistan is relatively scattered, with the highest threatened species richness in the Hissar-Darvasian A region. (4) Protected areas cover approximately 22% of Tajikistan's territory; however, their boundaries do not fully align with regions of higher species richness. The protection level in key areas is insufficient and requires strengthening.

Keywords: Tajikistan; plant diversity; threatened plant; distribution pattern; conservation gaps

Introduction

Conservation of threatened species constitutes a critical component of biodiversity research. To mitigate species extinction rates, it is essential to determine the endangerment status, distribution patterns, and conservation gaps of threatened species, and to implement timely protective measures. According to the International Union for Conservation of Nature (IUCN) Red List Categories and Criteria, the “threatened” category comprises three levels: Critically Endangered, Endangered, and Vulnerable. Threatened species lists serve as metrics for extinction risk and are key indicators of global biodiversity health, encompassing both the globally focused IUCN Red List and national red lists. The IUCN Red List provides early warnings about global species endangerment and forms the foundation for biodiversity conservation research at the global scale, whereas national red lists focus on country-level assessments, filling data gaps for endangered species at the regional level. These two lists are complementary; in principle, they should be integrated to evaluate plant species threats more comprehensively and accurately, thereby establishing strategic goals for biodiversity conservation.

Tajikistan has conducted national assessments of its plant species, resulting in the *Red List of Tajikistan*. The 2015 edition includes 228 rare and endangered plant species. Nowak et al. [8] assessed the threatened status of all wild plant groups in Tajikistan and analyzed relationships between specific endangered taxa and biological, ecological, and climatic factors. Additional studies have focused on particular endangered species and regions. However, few studies have comparatively analyzed the IUCN Red List alongside the Tajikistan Red List.

1.1 Study Area

Tajikistan (36°40' -41°05' N, 67°31' -75°14' E) is a landlocked mountainous country in southeastern Central Asia, covering an area of 14.35×10^4 km². Mountains and plateaus account for 93% of its territory. The substantial variation in geographic location and altitude contributes to its high biodiversity. The entire nation lies within the southern arid zone and the alpine system of the Eurasian continental interior deserts, with elevations ranging from 300 to 7,495 m, mostly above 3,000 m. The climate is typically continental, intensifying with altitude in high mountain regions and creating significant temperature variations between north and south. Tajikistan borders Xinjiang, China to the east and southeast, Afghanistan to the south, Uzbekistan to the west, and Kyrgyzstan to the north, with a total border length of 3,000 km, extending 700 km east-west and 350 km north-south. The country's major ecosystems include forests, alpine zones, arid regions, shrublands, grasslands, semi-deserts, and wetlands, with vegetation transitioning from grassland communities in the west to semi-desert and desert habitats in the south. Tajikistan has been designated a

biodiversity hotspot by Conservation International (CI). The nation hosts 177 families, 944 genera, and approximately 5,000 species of wild vascular plants. However, Tajikistan's biodiversity is being lost at an alarming rate. Currently, the areas of medicinal plants, rare fruit forests, and pastures in Tajikistan (particularly in mountainous regions) are rapidly diminishing. Additionally, global environmental changes, such as climate warming and extreme weather events, are reducing survival opportunities for climate-sensitive species.

1.2 Data Sources

Data sources include: (1) The 2015 edition of the Tajikistan Red List [NRL (2015)] and the third edition of the 2022 IUCN Red List [IUCN-RL (2022)]. (2) Scientific names of threatened species were verified using the Plants of the World Online (POWO, 2023), with authors following the International Plant Names Index (IPNI). Species not validly published were excluded. (3) Species distribution data were obtained from the *Flora of Tajikistan* and its supplements, the vascular plant checklist and distribution dataset published by Nowak et al. [8], distribution information from Nowak et al. [9], and original species publication literature. (4) Specimen records from the Global Biodiversity Information Facility (GBIF) database. (5) Spatial distribution data for threatened species published by the IUCN Red List.

1.3 Research Methods

This study employs GIS layer overlay and gap analysis (GAP) methods. Using ArcGIS 10.8 software and based on Tajikistan's national boundaries, the country was divided into seven phyto-geographical regions according to Goncharov's classification system from the *Flora of Tajikistan*. The APG IV system was used for angiosperms, the PPG I system for lycophytes and ferns, and the Olonova system for gymnosperms. Species composition was analyzed at family and genus levels, including: (1) families and genera containing more than 10 species, (2) those containing 6–10 species, (3) those containing 2–5 species, and (4) monotypic families and genera, calculating their proportions relative to total families and genera. Threat level differences between global and national assessments were compared using NRL (2015) and IUCN-RL (2022) data. The spatial distribution of threatened species was mapped based on IUCN-RL (2022) data and distribution information, creating a richness pattern map according to the number of threatened species in each region. Protected area data and spatial layers were obtained from the World Database on Protected Areas [48]. Overlay analysis of protected area distribution and threatened species richness patterns was conducted using ArcGIS 10.8 to identify conservation gaps.

2 Results

2.1 Species Composition Differences

A total of 228 threatened species are recorded in NRL (2015), all angiosperms. The IUCN-RL (2022) includes 228 threatened species, comprising 224 angiosperms and 4 gymnosperms. Combined, the two lists contain 232 threatened species (228 angiosperms and 4 gymnosperms), with 11 species common to both. In NRL (2015), families containing more than 10 species include Fabaceae (15 species) and Amaryllidaceae (12 species), accounting for 6.90% of total families. Families with 6–10 species include Apiaceae, Asteraceae, and Liliaceae (10 species each), representing 10.34% of total families and 13.04% of total genera. Families with 2–5 species include Brassicaceae, Cleomaceae, Lythraceae, and Cornaceae, among others. In IUCN-RL (2022), families with more than 10 species include Liliaceae (13 species) and Amaryllidaceae (12 species). Families with 6–10 species include Apiaceae, Asteraceae, Iridaceae, and Rosaceae. The genera with the highest number of threatened species in both lists are *Allium*, *Tulipa*, and *Ferula*.

2.2 Threat Level Assessment Differences

Among the 11 species common to both red lists, six species are assessed at higher threat levels in IUCN-RL (2022) than in NRL (2015), four at lower levels, and one at the same level. Species with higher threat levels in IUCN-RL (2022) include *Tulipa anisophylla* (Endangered in IUCN-RL vs. Vulnerable in NRL) and *Tulipa subquinquefolia* (Vulnerable in IUCN-RL vs. Endangered in NRL). Species with lower threat levels include *Tulipa praestans* (Vulnerable in IUCN-RL vs. Endangered in NRL), *Tulipa fosteriana* (Vulnerable in IUCN-RL vs. Endangered in NRL), *Cornus darvasica* (Endangered in IUCN-RL vs. Vulnerable in NRL), *Crataegus darvasica* (Vulnerable in IUCN-RL vs. Endangered in NRL), *Zygophyllum darvasicum* (Vulnerable in IUCN-RL vs. Critically Endangered in NRL), *Zygophyllum bucharicum* (Vulnerable in IUCN-RL vs. Critically Endangered in NRL), *Prunus tadjikistanica* (Vulnerable in IUCN-RL vs. Endangered in NRL), and *Pyrus cajon* (Vulnerable in IUCN-RL vs. Endangered in NRL). These discrepancies primarily result from differences in assessment scale, classification perspectives, substantive changes in species status, and incomplete evaluation data.

2.3 Threatened Species Distribution Patterns

The distribution of threatened species across Tajikistan's geographic regions is relatively dispersed. The Hissar-Darvasian A region exhibits the highest threatened species richness. Protected areas cover approximately 22% of the country's territory, with their distribution unevenly concentrated in the eastern part of the country. The boundaries of protected areas do not fully coincide with regions of high threatened species richness. South Tajikistan, despite having high species richness, lacks corresponding protected areas. East Tajikistan,

East Pamir, and West Pamir have lower threatened species richness but high protected area coverage, indicating an imbalance in protected area allocation.

[Figure 1: see original paper]

[Figure 2: see original paper]

3 Discussion

Allium species face multiple threats including habitat destruction, grazing, habitat conversion to cropland, and collection, with grazing being the most significant (37.5%). *Tulipa* species are threatened by road construction, large-scale collection, bulb digging for trade or consumption, habitat conversion, grazing, and mining, with grazing and large-scale collection each accounting for 25%. *Ferula* species are threatened by pastoralism, mining, collection of aromatic stems and resin extraction, and agriculture, primarily distributed on rocky slopes where grazing and mining destroy habitats.

Assessment discrepancies between global and national scales arise from several factors. Classification perspective differences affect species like *Tulipa praestans* and *Tulipa subquinquefolia*, where taxonomic treatments vary between sources. Assessment scale differences impact species like *Tulipa fosteriana*, which is primarily distributed in Uzbekistan rather than Tajikistan, resulting in a lower global threat level. Incomplete information and delayed updates also contribute to discrepancies, as seen in *Cornus darvasica* and *Crataegus darvasica*, where population changes are not reflected in timely assessments. These issues highlight deficiencies in Tajikistan's threatened species monitoring and information updating systems.

Previous studies have emphasized that Tajikistan's endemic species face intensive grazing, soil erosion, and desertification. Overgrazing and agricultural cultivation have severely damaged species habitats, while illegal logging and overgrazing cause irreversible damage to biodiversity. These findings align with our conclusions, confirming the severe negative impacts of grazing on the region's ecosystems.

4 Conclusions and Recommendations

4.1 Conclusions

A total of 228 threatened species are recorded in NRL (2015) and 228 in IUCN-RL (2022), with 232 species in total when including gymnosperms. Eleven species are common to both lists, most showing threat level discrepancies, with more species having higher threat levels in the IUCN-RL (2022). The primary causes of these differences are assessment scale, inconsistent classification perspectives, substantive changes in species status, and incomplete evaluation data.

Threatened species are distributed across all geographic regions, with the highest richness in Hissar-Darvasian A. Protected areas cover only 22% of Tajikistan's territory, below the international target of 30% set by the post-2020 Global Biodiversity Framework. Protected area distribution is unbalanced, with inadequate coverage in high-richness regions like South Tajikistan.

4.2 Recommendations

To improve conservation of threatened plants in Tajikistan, we recommend: (1) Adopting consistent classification perspectives during red list assessments to reduce discrepancies; (2) Conducting in-depth taxonomic research on disputed species to clarify their status; (3) Enhancing monitoring of threatened species populations and habitats, and updating assessments promptly with complete information; (4) Prioritizing protection efforts in regions with high threatened species richness but inadequate protection, particularly South Tajikistan; (5) Implementing appropriate grazing management to control intensity and frequency; (6) Enforcing environmental protection measures during wood harvesting and mining to minimize vegetation and habitat damage; (7) Establishing regulations to control illegal plant collection and promoting alternatives; and (8) Strengthening public awareness of biodiversity conservation.

References

- [1] Safarov N, Khisoriev Kh, Shermatov Kh. Plant diversity in Tajikistan and present conservation status of their rare and endangered species[J]. *Izvestiya Akademii Nauk Respubliki Tadjikistan Otdelenie Biologicheskikh i Meditsinskikh Nauk*, 2019(4): 7-12.
- [2] Cao Xiaomeng, Chen Lin, Pan Tingting, et al. Conservation status and priority of rare and endangered plants in Jiangxi Wuyishan National Nature Reserve[J]. *Journal of Nanjing Forestry University (Natural Sciences Edition)*, 2024, 48(5): 39-47.
- [3] An Huijun, Liu Jiahui, Zhang Tao. Study on definition of endangering standard of exclusive plants in eastern Alashan western Erdos[J]. *Journal of Arid Land Resources and Environment*, 2005, 19(1): 194-200.
- [4] Mounce R, Rivers M, Sharrock S, et al. Comparing and contrasting threat assessments of plant species at the global and sub global level[J]. *Biodiversity and Conservation*, 2018, 27(4): 907-930.
- [5] Xie Yan. Progress and application of IUCN red list of threatened species[J]. *Biodiversity Science*, 2022, 30(10): 66-83.
- [6] Jiang Zhigang, Jiang Jianping, Wang Yuezhao, et al. Significance of country red lists of endangered species for biodiversity conservation[J]. *Biodiversity Science*, 2020, 28(5): 558-565.

- [7] Nobis M, Nowak A. New data on the vascular flora of the central Pamir Alai Mountains (Tajikistan, Central Asia)[J]. *Polish Botanical Journal*, 2011, 56(2): 195-201.
- [8] Nowak A, wierszcz S, Nowak S, et al. Red list of vascular plants of Tajikistan: The core area of the Mountains of Central Asia global biodiversity hotspot[J]. *Scientific Reports*, 2020, 10(1): 6235, doi: 10.1038/s41598-020-63333-9.
- [9] Nowak A, Nowak S, Nobis M. Distribution patterns, ecological characteristic and conservation status of endemic plants of Tajikistan: A global hotspot of diversity[J]. *Journal for Nature Conservation*, 2011, 19(5): 296-305.
- [10] Ning W, Rawat G S, Joshi S, et al. High altitude rangelands and their interfaces in the Hindu Kush Himalayas[M]. Kathmandu: International Centre for Integrated Mountain Development, 2013: 43-61.
- [11] Hisorev H. Red date book of the Tajikistan[M]. Dushanbe: Izdatelstvo Donish, 2015: 1-536.
- [12] Squires V, Safarov N. Diversity of plants and animals in mountain ecosystems in Tajikistan[J]. *Journal of Rangeland Science*, 2013, 4(1): 43-61.
- [13] Olonova M, Gudkova P, Navruzshoev D, et al. Endemic and relic species plants of Badakhshsan (Pamirs) and new approach to their conservation[J]. *Ukrainian Journal of Ecology*, 2020, 10(6): 137-143.
- [14] IUCN. The IUCN red list of threatened species (Version 2023-1)[DB/OL]. [2023-11-20]. <https://www.iucnredlist.org>.
- [15] Wu Wanhu. The water resources of Tajikistan and runoff response to climate change[D]. Urumqi: Xinjiang Agricultural University, 2013.
- [16] Chen Aijun, Zhang Yin, Chu Zhigang. Spatiotemporal distribution of precipitation in five Central Asian countries based on FY-4A quantitative precipitation estimates[J]. *Arid Zone Research*, 2023, 40(9): 1369-1381.
- [17] Tahan Wumailxat, Wei Yan, Khyldlov Z Y. The vegetation characteristics of Hissar Mountain in Tajikistan[J]. *Journal of Anhui Agricultural Sciences*, 2013, 41(16): 7272-7273.
- [18] Huang Junhua, Zhai Shenxiu, Yao Yuxian, et al. Seed plant flora of Tajikistan[J]. *Arid Land Geography*, 2013, 36(4): 584-590.
- [19] Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew[DB/OL]. [2023-11-20]. <https://powo.science.kew.org/>.
- [20] International Plant Names Index. The Royal Botanic Gardens, Kew, Harvard University Herbaria & Libraries and Australian National Botanic Gardens[DB/OL]. [2023-11-12]. <http://www.ipni.org/>.
- [21] Ovchinnikov P N. Flora Tadzhikskoi SSR (vol. I)[M]. Moskwa: Izdatelstvo Nauka, 1957: 1-547.

- [22] Ovchinnikov P N. Flora Tadzhikskoi SSR (vol. II)[M]. Moskwa: Izdatelstvo Nauka, 1963: 1-456.
- [23] Ovchinnikov P N. Flora Tadzhikskoi SSR (vol. III)[M]. Moskwa: Izdatelstvo Nauka, 1968: 1-710.
- [24] Ovchinnikov P N, Kochkareva T F. Flora Tadzhikskoi SSR (vol. IV)[M]. Moskwa: Izdatelstvo Nauka, 1975: 1-576.
- [25] Ovchinnikov P N. Flora Tadzhikskoi SSR (vol. V)[M]. Moskwa: Izdatelstvo Nauka, 1978: 1-678.
- [26] Ovchinnikov P N, Kinzikaeva G. Flora Tadzhikskoi SSR (vol. VI)[M]. Moskwa: Izdatelstvo Nauka, 1981: 1-725.
- [27] Chukavina A P. Flora Tadzhikskoi SSR (vol. VII)[M]. Moskwa: Izdatelstvo Nauka, 1984: 1-562.
- [28] Kochkareva T F. Flora Tadzhikskoi SSR (vol. VIII)[M]. Moskwa: Izdatelstvo Nauka, 1986: 1-519.
- [29] Kinzikaeva G K. Flora Tadzhikskoi SSR (vol. IX)[M]. Moskwa: Izdatelstvo Nauka, 1988: 1-568.
- [30] Rasulova M R. Flora Tadzhikskoi SSR (vol. X)[M]. Moskwa: Izdatelstvo Nauka, 1991: 1-619.
- [31] Tsvelev N N. Zlaki SSSR[M]. Moskwa: Izdatelstvo Nauka, 1976: 1-788.
- [32] Ikonnikov S S. Notes on the flora of Pamir and Badakhshan[J]. *Novosti Sistematiki Vysshikh Rastenii*, 1983, 20: 187-195.
- [33] Machm A M. *Salvia tianschanica*[J]. *Novosti Sistematiki Vysshikh Rastenii*, 1980, 17: 215.
- [34] Hedgee I C. Studies in the flora of Afghanistan III: An account of *Salvia*[J]. *Notes from the Royal Botanic Garden Edinburgh*, 1966, 26: 407-425.
- [35] GBIF. Global biodiversity information facility[DB/OL]. [2023-11-20]. <https://www.gbif.org/>.
- [36] Workshop K. *Tulipa hissarica* (spatial data): The IUCN red list of threatened species[DB/OL]. [2023-11-20]. <https://www.iucnredlist.org>.
- [37] Workshop K. *Tulipa anisophylla* (spatial data): The IUCN red list of threatened species[DB/OL]. [2023-11-20]. <https://www.iucnredlist.org>.
- [38] Workshop K. *Tulipa kaufmanniana* (spatial data): The IUCN red list of threatened species[DB/OL]. [2023-11-20]. <https://www.iucnredlist.org>.
- [39] Workshop K. *Tulipa praestans* (spatial data): The IUCN red list of threatened species[DB/OL]. [2023-11-20]. <https://www.iucnredlist.org>.
- [40] Workshop K. *Tulipa subquinquefolia* (spatial data): The IUCN red list of threatened species[DB/OL]. [2023-11-20]. <https://www.iucnredlist.org>.

- [41] Group T A P. An update of the angiosperm phylogeny group classification for the orders and families of flowering plants: APG IV[J]. *Botanical Journal of the Linnean Society*, 2016, 181(1): 1-20.
- [42] Group T P P, Schuettpelz E, Schneider H, et al. A community-derived classification for extant lycophytes and ferns[J]. *Journal of Systematics and Evolution*, 2016, 54(6): 563-603.
- [43] Christenhusz M J M. A linear sequence of extant lycophytes and ferns[J]. *Phytotaxa*, 2011, 19(1): 7-54.
- [44] Christenhusz M J, Govaerts R, David J C, et al. Tiptoe through the tulips cultural history, molecular phylogenetics and classification of Tulipa (Liliaceae)[J]. *Botanical Journal of the Linnean Society*, 2013, 172(3): 280-328.
- [45] Dong Ziyang, Ma Le, Gao Shuhan. Potential habitat prediction of *Tetraena mongolica* and its GAP analysis with nature reserves[J]. *Arid Land Geography*, 2023, 46(4): 595-603.
- [46] UNEP-WCMC. Protected area profile for Tajikistan from the world database on protected areas[DB/OL]. [2023-12-10]. <https://www.protectedplanet.net>.
- [47] Breyer T M, Hurni H. The Tajik Pamirs: Challenges of sustainable development in an isolated mountain region[M]. Berne: Centre for Development and Environment (CDE) University of Berne, 2003: 43-61.
- [48] Akhmadov K M, Breckle S W, Breckle U. Effects of grazing on biodiversity, productivity, and soil erosion of alpine pastures in Tajik Mountains[C]//Spehn E M, Liberman M, Korner C. Land Use Change and Mountain Biodiversity. Miami: CRC Press, 2006: 241-249.
- [49] Squires V R, Safarov N. High altitude ecosystems and biodiversity of Tajikistan: Conservation and management[C]//Rawat G S, Joshi S, Ismail M, et al. High Altitude Rangelands and Their Interfaces in the Hindu Kush Himalayas. Kathmandu: ICIMOD, 2013: 78-91.
- [50] Nowak A, Nobis M. Tentative list of endemic vascular plants of the Zeravshan Mts in Tajikistan: Distribution, habitat preferences and conservation status of species[J]. *Biodiversity Research and Conservation*, 2010, 19: 65-80.
- [51] Jackson P W, Kennedy K. The global strategy for plant conservation: A challenge and opportunity for the international community[J]. *Trends in Plant Science*, 2009, 14(11): 578-580.
- [52] Paton A, Lughadha E M. The irresistible target meets the unachievable objective: What have 8 years of GSPC implementation taught us about target setting and achievable objectives?[J]. *Botanical Journal of the Linnean Society*, 2011, 166(3): 250-260.
- [53] Huang Qiusong, He Hao. Ecological security pattern of the oasis area around the Tarim Basin based on coupled ecosystem services and landscape connectivity[J]. *Arid Land Geography*, 2024, 47(10): 1745-1754.

- [54] Shan Zhangjian, Que Ling, Chen Shunan, et al. Analyses on distribution characteristics and conservation status of medicinal vascular plants in Jiangxi Province[J]. *Journal of Plant Resources and Environment*, 2020, 29(3): 50-57.
- [55] Scott J M, Davis F, Csuti B, et al. Gap analysis: A geographic approach to protection of biological diversity[J]. *Wildlife Monographs*, 1993, 123(3): 3-41.
- [56] CBD. A new global framework for managing nature through 2030: First detailed draft agreement debuts[EB/OL]. [2021-06-07]. <https://www.cbd.int/article/draft-1-global-biodiversity-framework>.

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv –Machine translation. Verify with original.