

Flora Analysis of Woody Plants in the Urad Desert Steppe (Postprint)

Authors: Zhao Xinghua, Ren Yatao, Zhao Hongsheng, Feng Shuang, Jia Rong, Lan Dengming

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Abstract

Using a method combining literature review and field investigation, wild woody plants in the Urad desert steppe were surveyed, statistically analyzed, and ranked, and the water ecological types and geographical components of the woody plants in this flora were analyzed. The results indicate that the flora of the Urad desert steppe comprises 85 species of wild woody plants, belonging to 27 families and 46 genera. Xerophytes dominate the water ecological types, with xerophytic species accounting for 78.82% of the total species count. The geographical components are overwhelmingly dominated by the Central Asian distribution type and the ancient Mediterranean distribution type, which collectively include 63 species, representing 74.14% of the total flora species. The flora contains 9 nationally rare and endangered plant species, belonging to 8 families and 8 genera, constituting 10.59% of the total flora species.

Full Text

Analysis of Woody Plant Flora in the Urad Desert Steppe

ZHAO Xinghua, REN Yatao, ZHAO Hongsheng, FENG Shuang, JIA Rong, LAN Dengming

College of Desertification Control Science and Engineering, Inner Mongolia Agricultural University, Hohhot 010019, Inner Mongolia, China

Abstract

Using a combination of literature review and field investigation, this study surveyed, catalogued, and analyzed the wild woody plants of the Urad desert steppe, examining their water ecotypes and geographic elements. The results revealed that the region harbors 85 species of wild woody plants belonging to 46 genera and 27 families. Xerophytes dominate the water ecotypes, comprising 78.82%

of all species. The geographic elements are overwhelmingly characterized by Middle Asian and Ancient Mediterranean distribution types, which together account for 63 species (74.14% of the total flora). The flora includes nine nationally protected rare and endangered plant species (10.59% of the total), distributed across eight families and eight genera.

Keywords: woody plants; plant flora; water ecotypes; geographic elements; rare and endangered plants; Urad desert steppe

Introduction

Desert steppe represents a transitional zone between grassland and desert ecosystems [1]. The Urad desert steppe, situated in northwestern Inner Mongolia at the boundary between semi-arid and arid regions, serves as a critical buffer zone for this transition [2]. Its unique geographic location and harsh habitat conditions render the ecosystem exceptionally vulnerable to intensifying human disturbances and global climate change, making its vegetation highly sensitive to both climatic fluctuations and anthropogenic impacts [3-5]. Previous research on the Urad desert steppe has primarily focused on responses to meteorological factors [6], the effects of grazing and precipitation on plant diversity and biomass in dominant communities [4,5,9-11], and soil microbial communities [7,8]. Growing season precipitation has been identified as the primary factor influencing community characteristics and plant biomass. Under the combined pressures of climate change and human activity, the Urad grassland exhibits clear signs of degradation [12,13]. As fundamental ecosystem components, the region's rodent species distribution and arthropod community characteristics have also attracted scholarly attention [14,15]. However, studies on the plant flora of this geographic unit remain scarce. Given that the dominant layers in the Urad desert steppe consist of perennial grasses and xerophytic shrubs and subshrubs, investigating the composition, characteristics, and geographic elements of the plant flora—particularly the woody plant flora—along with the water ecotypes of constituent species, is essential for understanding current vegetation structure, floristic origins, evolutionary history, and for guiding rational plant resource development and utilization.

1.1 Study Area Overview

The Urad desert steppe is located in northern Bayannur City, Inner Mongolia, connecting with the extensive desert steppe of Mongolia to the north, bounded by the northern foothills of the Yinshan Mountains to the south, extending westward to Alxa Left Banner, and bordering Baotou City to the east. Administratively, it falls within Urad Middle Banner and Urad Rear Banner, with geographic coordinates of 105°13' -109°43' E and 40°43' -42°27' N. Floristically, the study area belongs to the Asian Desert Floristic Region, East Alxa Desert Province, and East Alxa Prefecture. From a vegetation zonation perspective,

it is classified within the desert steppe subzone of the temperate steppe zone, characterized by a strongly continental climate with mean annual temperatures of 3-6°C, $\Sigma 10^{\circ}\text{C}$ accumulated temperatures of 2200-2500°C, and average annual precipitation of 150-250 mm. Several intermittent rivers originate from the Yinshan Mountains and flow northward. The terrain generally slopes from higher elevations in the south to lower elevations in the north, creating numerous narrow dry river channels and small salt lakes on the high plain that provide habitats for saline meadows and halophytic vegetation [16].

1.2.1 Field Investigation

This study integrated literature review with field investigation. Field surveys were conducted under the National Basic Resources Survey Project of the Ministry of Science and Technology (2017FY100204). Using the 1:1,000,000 China Vegetation Distribution Map as a base, sample points were evenly distributed across the study area according to vegetation community types identified on remote sensing imagery. A total of 85 sample plots were established, with latitude and longitude coordinates recorded for each location. Ground surveys employed conventional ecological methods, documenting species lists, measuring coverage, density, frequency, dominance, and biomass (the “four degrees and one quantity”), and collecting plant specimens and soil samples for laboratory analysis (Fig. 1). Each plot comprised a 100 m \times 100 m macroplot, with five shrub quadrats (5 m \times 5 m) positioned at the four corners and center of the macroplot.

[Figure 1: see original paper]

1.2.2 Plant Catalog Establishment

Based on field investigations and records from the *Flora of Inner Mongolia* (2nd edition) [2,15-18], we identified habitat types and established a catalog of woody plant species for the study area. Questionable species were verified against herbarium specimens housed at Inner Mongolia Agricultural University.

2.1 Species Composition

The Urad desert steppe contains 85 species of wild woody plants (including infraspecific taxa; hereafter the same), belonging to 46 genera and 27 families [2,15-18]. This includes 2 gymnosperm species and 83 angiosperm species; 81 shrub species (including subshrubs), 2 tree species (including small trees), and 2 woody liana species. The flora encompasses both relatively primitive families such as Ephedraceae and more evolutionarily advanced families such as Asteraceae. The five most species-rich families are Leguminosae (17 species), Asteraceae (11 species), Chenopodiaceae (9 species), Rosaceae (7 species), and Tamaricaceae (5 species), collectively comprising 49 species (57.65% of the total flora). Dominant families are defined as those with numerous species that are most common in vegetation communities [20,24-25]. Analysis of the cumulative contribution rate of the top n families to the total flora (Fig. 2) shows that

the top 10 families contain 64 species, representing 75.29% of the total flora, confirming their status as dominant families with absolute predominance. Families with only a single species account for 15.34% of the total flora; these are primarily distributed in transitional boundary areas or as companion species of dominant plants, contributing minimally to overall floristic composition.

[Figure 2: see original paper]

1.2.3 Water Ecotype Classification

Classification of plant groups based on water conditions is termed water ecotype. According to the classification system developed by plant ecologists Warming and Schimper, plants are categorized as xerophytes, mesophytes, hygrophytes, and hydrophytes [1,19]. Based on habitat adaptation, xerophytes can be subdivided into ultra-xerophytes, strong xerophytes, typical xerophytes, and meso-xerophytes; mesophytes into xero-mesophytes, typical mesophytes, and hygromesophytes; and hygrophytes into meso-hygrophytes and hygrophytes [1,19].

2.2 Water Ecotypes

Plant distribution reflects long-term environmental adaptation, with soil moisture, salinity, temperature, and solar radiation serving as decisive factors. The woody plant flora of the Urad desert steppe is dominated by xerophytes, with no hygrophytes or hydrophytes present (Fig. 3). Xerophytes total 67 species in 40 genera, accounting for 78.82% of the flora. Ultra-xerophytes comprise 9 species in 8 genera, including *Ephedra przewalskii*, *Salsola passerina*, *Salsola arbuscula*, *Gymnocarpus przewalskii*, *Nitraria sphaerocarpa*, *Reaumuria soongorica*, *Asterothamnus centrali-asiaticus*, *Brachanthemum gobicum*, and *Artemisia sphaerocephala* (10.59% of the flora). Strong xerophytes include 35 species in 21 genera, such as *Calligonum mongolicum*, *Anabasis brevifolia*, *Haloxylon ammodendron*, *Ceratooides latens*, *Potaninia mongolica*, and *Ammopiptanthus mongolicus* (41.18% of the flora). Typical xerophytes consist of 21 species in 15 genera, including *Ephedra sinica*, *Ephedra equisetina*, *Atraphaxis pungens*, *Kochia prostrata*, *Amygdalus mongolica*, *Nitraria tangutorum*, *Nitraria sibirica*, and *Artemisia ordosica* (24.71% of the flora). Meso-xerophytes comprise only 2 species in 2 genera: *Populus euphratica* and *Caragana opulens* (2.35% of the flora). Mesophytes total 18 species in 13 genera (21.18% of the flora), including xero-mesophytes such as *Juniperus rigida*, *Ziziphus jujuba* var. *spinosa*, *Rhamnus parvifolia*, and *Ptilotrichum tenuifolium* (11.76% of the flora), and typical mesophytes such as *Morus mongolica*, *Xanthoceras sorbifolia*, *Ampelopsis aconitifolia*, and *Lycium ruthenicum* (9.41% of the flora).

The dominant layers of desert steppe are formed by xerophytic perennial grasses, followed by xerophytic subshrub layers. Annual and biennial herbs increase substantially after summer rains, but contribute minimally to flora construction and regional ecological stability during drought years. Common subshrubs include *Caragana intermedia*, *Caragana stenophylla*, *Caragana pygmaea*, and *Ajania*

achilleoides, which serve as constructive species in xerophytic shrub communities, while *Ptilotrichum canescens* and *Oxytropis aciphylla* are characteristic species of desert steppe. Field surveys and specimen collection revealed species not documented in literature, including *Reaumuria soongorica*, *Salsola passerina*, *Salsola laricifolia*, *Zygophyllum xanthoxylon*, *Nitraria tangutorum*, *Nitraria sphaerocarpa*, *Caragana korshinskii*, *Caragana tibetica*, and *Anabasis brevifolia*. These xerophytic and strong xerophytic species represent typical desert components, indicating that the study area is experiencing increasing aridity and that desert steppe flora is gradually evolving toward desert flora—a consequence of both global climate change and anthropogenic habitat degradation.

[Figure 3: see original paper]

1.2.4 Plant Distribution Type Classification

Plant distribution area refers to the geographic range of taxonomic units (family, genus, species), representing their total distribution in space [20]. This study classified distribution types of woody plant species according to the principles and methods of Wang Hesheng [20], Zhao Yizhi [21], and Wu Zhengyi [22].

2.3 Geographic Composition Analysis of Plant Species

Species are the fundamental entities constituting plant flora, and analyzing their geographic composition is more meaningful than analyzing families or genera [24,26]. Species distribution patterns are products of long-term evolution, shaped by climate and environmental changes through gradual dispersal, migration, and differentiation [20,27]. Following the classification systems of Wang Hesheng [20], Zhao Yizhi [21], and Wu Zhengyi [22], the 85 woody plant species in the Urad desert steppe were categorized into 7 distribution types and 4 distribution variants (Table 2).

The Middle Asian distribution type dominates with 45 species (52.94% of the total), holding absolute predominance in this flora. The Ancient Mediterranean distribution type includes 18 species (21.18%). The East Ancient Arctic and East Asian distribution types each contain 11 species (12.94% each). The Middle Asian distribution type comprises typical Middle Asian distribution (21 species, 24.71%) and two variants: Gobi-Mongolian distribution (18 species, 21.18%) and Alashan distribution (6 species, 7.06%). Common Gobi-Mongolian species include *Calligonum mongolicum*, *Atraphaxis pungens*, *Haloxylon ammodendron*, *Salsola passerina*, *Kalidium gracile*, *Ptilotrichum canescens*, *Oxytropis aciphylla*, *Reaumuria soongorica*, *Asterothamnus centrali-asiaticus*, *Ajania achilleoides*, *Ajania fruticulosa*, *Artemisia xerophytica*, and *Asparagus gobicus*. Common Alashan species include *Potaninia mongolica*, *Amygdalus mongolica*, *Caragana brachypoda*, *Caragana korshinskii*, *Haplophyllum tragacanthoides*, *Reaumuria trigyna*, and *Brachanthemum gobicum*. The Gobi-Mongolian distribution and its Alashan variant collectively include 24 species (28.24% of the flora), demonstrating typical regional characteristics. Common Ancient Mediterranean species in-

clude *Ephedra equisetina*, *Ephedra intermedia*, *Populus euphratica*, *Ceratoides latens*, *Salsola arbuscula*, *Kalidium foliatum*, *Nitraria sibirica*, *Nitraria tangutorum*, *Nitraria roborowskii*, *Tamarix ramosissima*, and *Lycium ruthenicum*.

The East Asian distribution type includes 11 species: East Asian distribution (2 species) and its variants—North China distribution (6 species) and North China-Hengduan Mountains distribution (3 species). East Asian species include *Morus mongolica* and *Flueggea suffruticosa*. North China distribution species include *Rosa xanthina* f. *normalis*, *Xanthoceras sorbifolia*, and *Ziziphus jujuba* var. *spinosa*. The North China-Hengduan Mountains distribution includes *Caragana opulens* and *Ajanía khartensis*. The East Ancient Arctic distribution type includes 11 species: East Ancient Arctic distribution (4 species), Mongolian-North China distribution (4 species), and East Asian North (Manchuria-Japan) distribution (3 species). East Ancient Arctic species include *Ulmus macrocarpa*, *Ulmus pumila*, *Spiraea trilobata*, and *Rhamnus parvifolia*. Mongolian-North China species include *Ephedra sinica*, *Caragana stenophylla*, and *Caryopteris mongholica*.

1.2.5 Determination of Rare and Endangered Plants

Rare and endangered species in the study area were identified according to the Information System of Rare and Endangered Plants in China—List of Rare and Endangered Plants in China [23].

2.4 Analysis of Rare and Endangered Plants and Endemic Species

The flora includes nine nationally rare and endangered plant species belonging to eight families and eight genera, representing 10.59% of the total flora (Table 3). Among these, two species are second-class nationally protected plants. The flora contains only one Chinese endemic species, *Nitraria tangutorum*, indicating low endemism. However, nearly half of all species are Alashan desert endemics, fully demonstrating the distinctive regional character of this flora.

3 Conclusions

- 1) The Urad desert steppe contains 85 species of wild woody plants belonging to 46 genera and 27 families. The five most species-rich families are Leguminosae, Asteraceae, Chenopodiaceae, Rosaceae, and Tamaricaceae. Xerophytes dominate, comprising 78.82% of the flora; remaining species are mesophytes, mostly distributed in transitional forest vegetation at flora boundaries or as companion species of dominant populations.
- 2) The geographic composition is characterized by simple types but strong regional specificity. Chinese endemic plants are scarce, yet typical desert plants hold absolute dominance. Due to harsh natural conditions and inherently restricted distribution ranges of some species, the flora contains a relatively high proportion of nationally rare and endangered plants (10.59% of the total flora).

- 3) As a desertified steppe, this flora exhibits a clear desertification trend, with numerous woody plants and a substantial proportion of desert components. Controlling grazing intensity, maintaining existing habitats for rare and endangered plants, and preserving grassland ecological balance are crucial for conserving vulnerable habitats in the grassland-desert transition zone.

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