



# OPEN Checklist and analysis of the vascular flora in river valleys of Altay region Xinjiang China

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The checklist of the vascular flora in the river valleys of the Altay region (Xinjiang, China) was painstakingly compiled. We synthesized data from a variety of sources, including relevant literature, online databases, herbarium collections, and three years of dedicated floristic field surveys. In total, we observed and collated information on 213 species, which belong to 45 families and 124 genera. Among the growth forms, herbs were preponderant, accounting for 89.20%, closely followed by shrubs at 9.39%. Notably, our research uncovered 5 species of endemics in China and 9 threatened species within the Altay Valley. For each species included in this checklist, we have presented detailed information such as growth form, voucher specimens, habitat, and distribution range. Our findings are not only crucial for river management and local community-based river conservation efforts in the Altay region but also hold significant value for conservationists worldwide. These results can serve as the foundation for making critical decisions aimed at safeguarding this invaluable biodiversity resource.

**Keywords** Biodiversity, Checklist, Floristic survey, Altay Valley

The biodiversity crisis has increased interest in conservation planning and prioritization strategies. Conservation of biodiversity has been a crucial priority for many countries in recent years, such as the United States, the United Kingdom, Australia, and China<sup>1–3</sup>. In particular, plant species inventories are crucial for botanical research and plant conservation, as they provide fundamental data regarding the measurement and distribution of biodiversity. The Xinjiang Uygur Autonomous Region is the largest administrative region in China. Its distinctive geography, topography, and climate have nurtured an abundant biodiversity<sup>4</sup>. Various ecosystems support a lot of vegetation types and species, but they remain exceptionally delicate<sup>5</sup>. This is mainly due to their high species diversity and complex food web structure<sup>6</sup>. The ecological barrier of Xinjiang needs sustained national attention, continual monitoring, and dedicated research efforts<sup>7</sup>.

The Altay Prefecture is subordinate to the Ili Kazak Autonomous Prefecture in Xinjiang and is located in the northernmost part of Xinjiang<sup>8,9</sup>. The region has a complex and diverse topography, with the Altay Mountains in the north, the Shawuer Mountains in the southwest, and the Junggar Basin in the south<sup>10</sup>. The Altay Valley is located in the arid and semi-arid region in the northwest of China. Despite the water shortage in the region, the broad river valleys, lateral seepage of groundwater, and yearly natural floods furnish the essential conditions for plant survival. Therefore, the Irtysh River, Sumu Dayerzhik River, and Kran River are important water sources in this area and play an important role in regional ecological protection. There are many different vegetation types distributed in the river valleys in the Altay region. River valleys, as crucial natural ecosystems, provide diversified ecological niches for many organisms and serve important ecological functions in protecting biodiversity<sup>11–13</sup>. Nevertheless, disturbance of vegetation or other environmental factors may trigger shifts in biodiversity patterns or ecosystem states in river valleys and other riparian or wet environments<sup>14</sup>.

Over the years, the ecology and species diversity within the river valleys in the Altay region have experienced some alterations due to agricultural practices, climate fluctuations, and developmental activities<sup>15,16</sup>. Therefore, for 2021–2024 years, our scientific expedition team collected and gathered specimens from this region and documented associated data for future scientific research.

The goal of this study is to provide a checklist of vascular plants in the river valleys in the Altay region. However, the arid climate, scant precipitation, and flat terrain serve to constrain the distribution of ferns and gymnosperms, thereby resulting in the exclusive collection of angiosperms specimens. Specific objectives were

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Top 10 species-rich families	
Family	Species
Poaceae	18
Rosaceae	16
Plantaginaceae	14
Asteraceae	13
Amaranthaceae	11
Brassicaceae	11
Lamiaceae	11
Polygonaceae	11
Ranunculaceae	9
Apiaceae	8

**Table 1.** Top 10 species-rich families of river valleys in the Altay region.

Top 10 species-rich genera	
Genus	Species
<i>Potentilla</i>	9
<i>Rumex</i>	8
<i>Tamarix</i>	7
<i>Veronica</i>	6
<i>Allium</i>	5
<i>Euphorbia</i>	5
<i>Salix</i>	5
<i>Iris</i>	4
<i>Plantago</i>	4
<i>Ranunculus</i>	4

**Table 2.** Top 10 species-rich genera of river valleys in the Altay region.

to provide (a) the updated checklist for the angiosperm plant composition of the river valleys in Altay region (Xinjiang, China); (b) the growth forms and habitats of all the angiosperm plants in the river valleys in Altay region (Xinjiang, China); and (c) the list of endemic and threatened angiosperms plants in the river valleys in Altay region (Xinjiang, China). The checklist will assist policymakers in making more informed decisions and appropriate strategies for conservation. It also provides a basis for further botanical and ecological studies in river valleys in the Altay region.

## Results

### Diversity of families, genera, and species

The current checklist includes 213 angiosperm species, belonging to 45 families and 124 genera, accounting for 5.5% of the total of 3875 species of vascular plants in the Flora of Xinjiang recorded.

The top five species-rich families in this checklist of angiosperms are Poaceae (8.45%), Rosaceae (7.51%), Plantaginaceae (6.57%), Asteraceae (6.20%), and Amaranthaceae (5.16%). The top five species-rich genera were *Potentilla* (Rosaceae), *Rumex* (Polygonaceae), *Tamarix* (Tamaricaceae), *Veronica* (Plantaginaceae), and *Allium* (Amaryllidaceae) (Tables 1 and 2).

### Plants growth forms

The growth pattern observed in the river valleys in the Altay region indicates that herbaceous species dominate, constituting the highest percentage at 89.20%, followed by shrubs (9.86%), trees (3.29%), and vines (0.47%) (Table 3). The richness of species is usually higher in the herbaceous layer than in any other stratum.

### Endemic and threatened species

There are 5 endemic plant species in river valleys in the Altay region, belonging to 5 families (Table 4). The region is not well protected, hence poses great danger to these species, for example, *Alisma nanum* D.F.Cui is classified as an endangered species by IUCN<sup>29</sup>. In total, there are 9 threatened plant species, belonging to 9 families and 9 genera in river valleys in the Altay region (Table 5).

Growth form	Species	Percentage of species recorded (%)
Herb	190	89.20
Shrubs	20	9.39
Subshrubs	1	0.47
Trees	7	3.29
Vines	1	0.47

**Table 3.** Growth forms of plant species of river valleys in Altay region.

Family	Species	Endemic to China or Xinjiang
Alismataceae	<i>Alisma nanum</i> D.F.Cui	Endemic to Xinjiang
Amarylidaceae	<i>Allium hymenorhizum</i> var. <i>dentatum</i> J.M.Xu	Endemic to Xinjiang
Fabaceae	<i>Astragalus eerqisiensis</i> Zhao Y.Chang	Endemic to Xinjiang
Salicaceae	<i>Populus × berolinensis</i> var. <i>jrtyschensis</i> (C.Y.Yang) C.Shang	Endemic to Xinjiang
Amaranthaceae	<i>Oxybasis micrantha</i> (Trautv.) Sukhor. & Uotila	Endemic to China

**Table 4.** List of endemic species in river valleys in the Altay region.

Family	Species	IUCN category
Alismataceae	<i>Alisma nanum</i> D.F.Cui	EN
Orchidaceae	<i>Orchis militaris</i> L.	EN
Plumbaginaceae	<i>Limonium gmelinii</i> (Willd.) Kuntze	VU
Plantaginaceae	<i>Plantago maxima</i> Ruch.	VU
Liliaceae	<i>Lilium martagon</i> var. <i>pilosiusculum</i> Freyn	NT
Asparagaceae	<i>Allium hymenorhizum</i> var. <i>dentatum</i> J.M.Xu	NT
Ranunculaceae	<i>Ranunculus altaicus</i> Laxm.	NT
Salicaceae	<i>Salix cinerea</i> L.	NT
Lamiaceae	<i>Lagochilus bungei</i> Benth.	NT

**Table 5.** List of threatened species in river valleys in the Altay region.

Discussion

A list of the angiosperm plants present in the river valleys in the Altay region is provided by the current checklist. With a total of 213 taxa in 124 genera in 45 families, it represents 0.68% of the total 31,142 vascular plants, 3.64% of the total 3408 genera, and 14.95% of the total 301 families of vascular plants in China<sup>17</sup>. Nevertheless, the richness depicted herein may undergo alterations with the emergence of newly described taxa, the synonymization of existing ones, the introduction of exotic or invasive species, and the potential extinction of others<sup>16,18</sup>.

In the study, some families are poorly represented in this region, with few individuals present, such as Nymphaeaceae, Acoraceae, Butomaceae, and Papaveraceae. The most species-rich families are Poaceae, Rosaceae, Plantaginaceae, Asteraceae, and Amaranthaceae. Threatened and near-threatened taxa in river valleys in the Altay region represent 2% of the total taxa recorded. Although these numbers may not seem significant when compared to the total, the likely loss of these species’ already limited habitats raises their localized extinction risk. Combined with over-harvesting and habitat degradation further exacerbates these threats<sup>19</sup>. There is a high percentage of species from river valleys in the Altay region have been evaluated to be of least concern (57.4%), and thus are not facing imminent risk. Nonetheless, notwithstanding their categorization as “Least Concern” (LC), several species exhibit declining trends in their natural habitats, potentially jeopardizing their survival without conservation interventions. The river valleys in the Altay region boast a diversity of endemic species. The rivers play an essential role in conserving the river valleys and are environmentally significant as they protect the ecosystem of Xinjiang<sup>10,20</sup>.

Sun et al.<sup>21</sup> found that plant community richness in riparian zones generally increases from downstream to upstream. Like this pattern, precipitation in the Junggar Basin displays a declining precipitation gradient from west to east, and the high mountains surrounding the Altay region trap topographic precipitation, allowing the region to form a “wet island”<sup>22</sup>. Although the Altay region is located in an arid zone, the local humidity is sufficient to support vegetation growth. As a result, the Altai region is home to most of the species on our list.

The habitat of wetlands is complex and changeable, with obvious seasonal characteristics of alternating wet and dry conditions, which puts forward higher requirements for the ecological adaptability of plant species. As the pioneer plants in the wetlands ecosystem, herbaceous plants are characterized by various species, fast turnover rate, and strong adaptability<sup>18</sup>. Herbs were the most prevalent growth forms recorded in river valleys

in the Altay region. The majority of plants struggle to survive in the basin's ecological circumstances, but certain taxa developed adaptations to deal with these challenges. The majority of plants in the basin belong to the typical desert mesophyte category.

These several river systems have exerted a pronounced influence on the diversity of plant species, community formations, and distribution patterns within its basin. Changes in the level of surface water are conducive to the germination and dissemination of seeds, which can promote the increase of species richness to a certain extent; while the groundwater level is the main limiting factor for vegetation communities in riparian zones in arid regions, that is, when the groundwater level changes from shallow to deep, the moisture-tolerant plants in the riparian zone will gradually be replaced by drought-tolerant plants, and at the same time, plant diversity will show a trend of first increasing and then decreasing<sup>23</sup>. Even slight variations in topography can cause a notable impact on the distribution of surface runoff and groundwater, leading to a distinct zonal distribution of plant communities<sup>24</sup>. Several different vegetation types have developed, such as *Artemisia santolina* comm., *Halimodendron halodendron* comm., *Achnatherum splendens* comm. Various factors determine their distribution, such as topography, climate-induced dryness, and precipitation, which exhibit a strong intrazonal character. Therefore, the survival of the ecosystem needs to manage and conserve the plant resources of the Irtysh River sustainably.

## Conclusion

This represents a current checklist of angiosperm plants in the river valleys in the Altay region, consolidating information from pertinent literature sources, herbarium collections, and authoritative botanical databases. In this study, we found 5 endemic species and 9 threatened species in river valleys in the Altay region. Efforts to ensure the conservation of the Altay region's flora, vegetation, and habitats should be prioritized with much emphasis on the endangered, rare, or endemic species, according to the checklist result, as suggested internationally by other authors. This checklist can represent a reliable basis for further botanical studies in river valleys in the Altay region.

## Methods

### Study site and current vegetation status

The Altay Prefecture is subordinate to the Ili Kazak Autonomous Prefecture in Xinjiang and is located in the northernmost part of Xinjiang (85°31'36"–91°04'23"E, 45°00'00"–49°10'45"N). Altay Prefecture is bordering on Russia, Kazakhstan, and Mongolia, with a total area of 118,000 km<sup>2</sup>. The terrain is high in the northeast and low in the southwest, with the Irtysh River and the Ulungur River running east-west across the entire region. The climate is characterized by dry and hot summers and severe cold winters, which is a typical continental climate in the cold region of the north temperate zone<sup>25</sup>. Meteorological data reveal, annual precipitation ranges from 400 to 600 mm in western/northern mountainous areas to 150–200 mm in southeastern plains, and further declining to approximately 95 mm in southern deserts. Mean annual temperature is 3.7 °C (with seasonal variations of plus or minus 30 °C), where plains experience temperatures above 4 °C while mountainous areas remain below 4 °C<sup>26</sup>.

The distinctive geographic positioning, topography, and climatic conditions of the basin foster a plethora of ecosystems, principally encompassing valley forests and grasslands, as well as the Ulungur Lake ecosystem (Figs. 1, 2, 3 and 4). These ecosystems offer unparalleled ecological, economic, and genetic services<sup>27</sup>. Due to climate, drainage, and geology, the water quality exhibits a distinct geographical distribution pattern and seasonal changes<sup>28,29</sup>.

Owing to the sandy soils and the formidable influence of winds, the arid sections of the Irtysh River valley give rise to desert plains characterized by scant vegetation and impoverished soils. The vegetation in the study area is mainly desert meadow and grassland, accounting for 91.58% of the whole vegetated area. The rest are herbaceous swamps distributed in and around the river valley, and broad-leaved forests or shrubs scattered in or near the swamp area (Figs. 5 and 6)<sup>30</sup>. Among the herbaceous species of the Altay region, *Glycyrrhiza inflata* Batalin, *Phragmites australis* (Cav.) Trin. ex Steud., are dominant<sup>31</sup>.

### Floristic surveys, specimen collection, and identification

Throughout the period spanning from May 2021 to July 2024, our botanical expedition conducted systematic floristic surveys in the river valleys of the Altay region, focusing on key watersheds including the Ertix River, Burqin River, Ulungur River, and Ulungur Lake (Fig. 7). The surveys were strategically scheduled during peak growing seasons across six sampling campaigns: May 2021, May 2022, July 2022, May 2023, July 2023, and July 2024. Each intensive survey lasted approximately 10–15 days to ensure full spatial and temporal coverage of the study area. A combination of a general walk-over survey method<sup>32</sup> and a plotless landscape-defined sampling method for plant specimen collection and sight observation was used to aid the characterization of the flora in the different vegetation types<sup>33</sup>. The specimens bearing flowers or fruit were collected and identified<sup>34</sup> by Prof. Zhixi Fu of the School of Life Sciences, Sichuan Normal University, and were deposited in herbarium 313, Sichuan Normal University Herbarium (SCNU!) (contact: Associate Prof. Zhixi Fu fuzx2017@sicnu.edu.cn) (see the checklist). Specimens from other collections were identified to species by the herbarium staff. The collection numbers are listed in appendix. Detailed information on identified specimens was recorded. It included habit, habitat, general distribution, and collector details. Species were classified as endemic if their distribution was confined to a specific geographic area, such as exclusively in China or solely in Xinjiang.

We also compiled the checklist from specimens collected and from electronic specimen data collected over the past decades of scientific research. Combined with Flora of China, Atlas of Wild Vascular Plants in Northern Xinjiang, Chinese Virtual Herbarium (CVH, <https://www.cvh.ac.cn/>), and National Plant Specimen



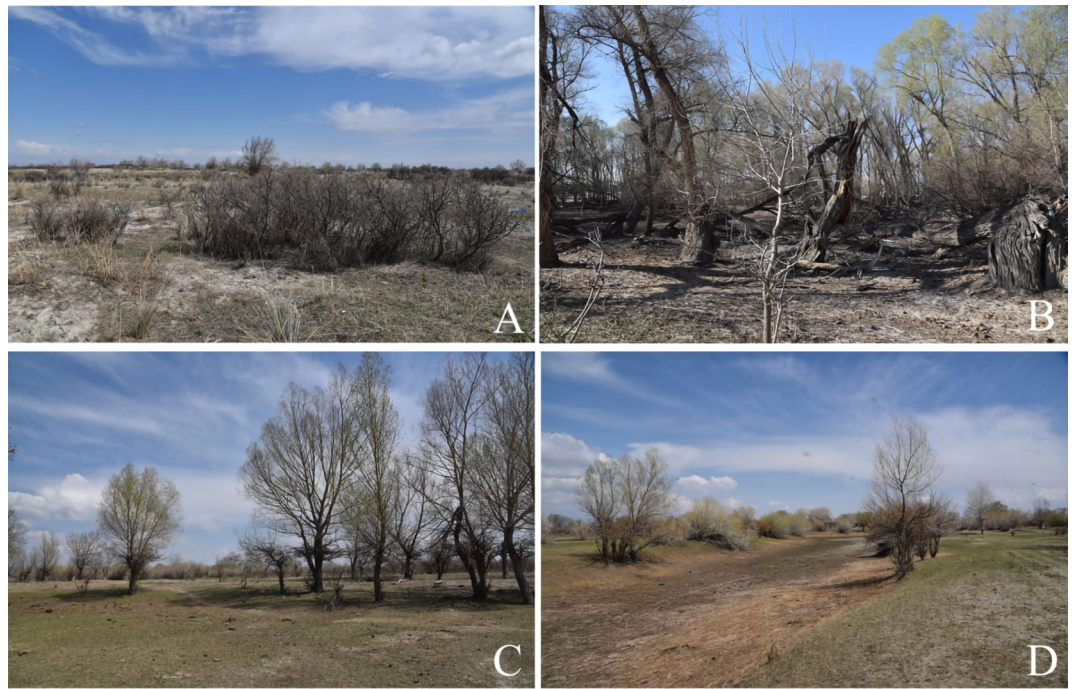


**Fig. 1.** Different plant communities along the river in river valleys in the Altay region (Xinjiang, China). (Photographed by Dr. Zhixi Fu)

Resource Center (NPSRC, <https://www.plantplus.cn/cn>) were used to identify the collected specimens. The national conservation status of all the angiosperm plant species collected was assessed using the criteria from the International Union for Conservation of Nature. The Information System of Chinese Rare and Endangered Plants (ISCREP, <http://www.iplant.cn/rep/protlist>) and IUCN<sup>35</sup> were consulted to assess the conservation status of all the species.

An annotated checklist of the vascular plants of the river valleys in the Altay region is presented below. Within this checklist, species are organized alphabetically in each family. Angiosperm classification and nomenclature follow APG IV<sup>36</sup> at the family level. For each taxon recorded, full authority is given, growth form, brief notes on habitat and distribution range, voucher specimen number, and the herbarium where it was deposited. The following lists of species include references to the elevation, and where meters are stated, this means meters above sea level. PE refers to the Herbarium, Institute of Botany, Chinese Academy of Sciences, BNU refers to the Herbarium, College of Life Sciences, Beijing Normal University, KUN refers to the Herbarium, Kunming Institute of Botany, Chinese Academy of Sciences, XJBI refers to the Herbarium, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, ISBC refers to the Herbarium, South China Botanical Garden, Chinese Academy of Sciences, WUK refers to the Herbarium, School of Life Sciences, Northwest Agriculture and Forestry University, SCNU refers to the Herbarium, College of Life Sciences, Sichuan Normal University. All acronyms are standardized according to Index Herbariorum (<https://sweetgum.nybg.org/science/ih/>) [accessed 14 April 2025].

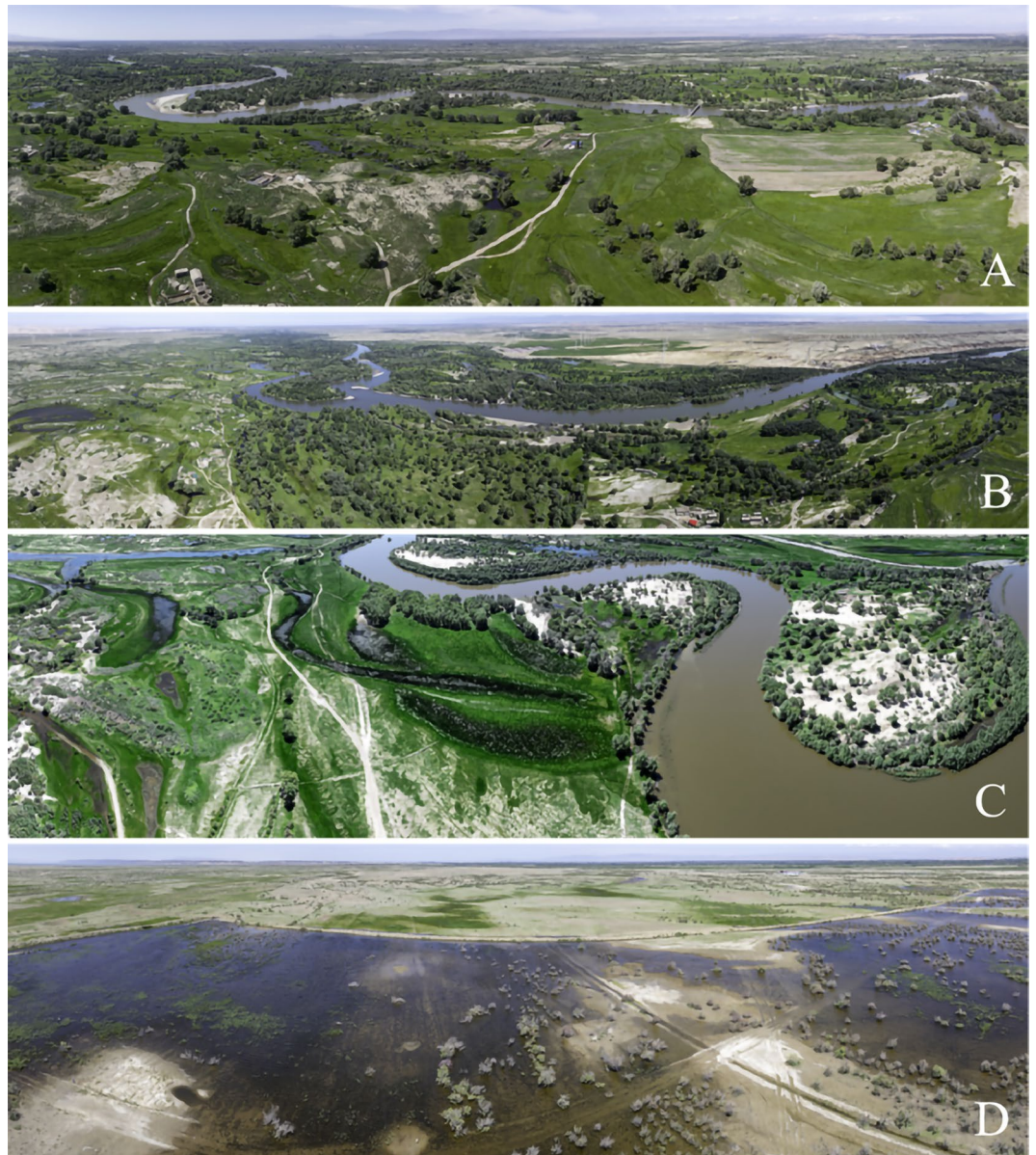
Growth forms of taxa collected were categorized as herbs (plants less than 50 cm high or less than 100 cm, but annual and without persistent woody stems), shrubs (plants between 50 cm and 5 m high with woody stems branching at or near the ground), climbers (plants with twining herbaceous or woody stems) and trees (plants taller than 5 m with a clear main trunk)<sup>37,38</sup>. Standard bibliographies, for example, Flora of Xinjiang Editorial Committee<sup>39</sup> were also used to define growth forms, particularly from herbarium specimens. The accuracy of



**Fig. 2.** Different plant communities in river valleys in the Altay region (Xinjiang, China). (Photographed by Dr. Zhixi Fu).

plant taxonomic circumscription and authorities for each taxon was verified using reference material from Flora of China.





**Fig. 3.** Aerial photographs in river valleys in Altay region (Xinjiang, China) **A** Beitun city **B** Colorful beach of Burqin county **C** Karakul of Kuqa County **D** Beitun. (Photographed by Dr. Shaoyao Zhang).



**Fig. 4.** Aerial photographs in river valleys in Altay region (Xinjiang, China) **A** Qinggil River **B** Ulungur lake **C** Haba River. (Photographed by Dr. Shaoyao Zhang).



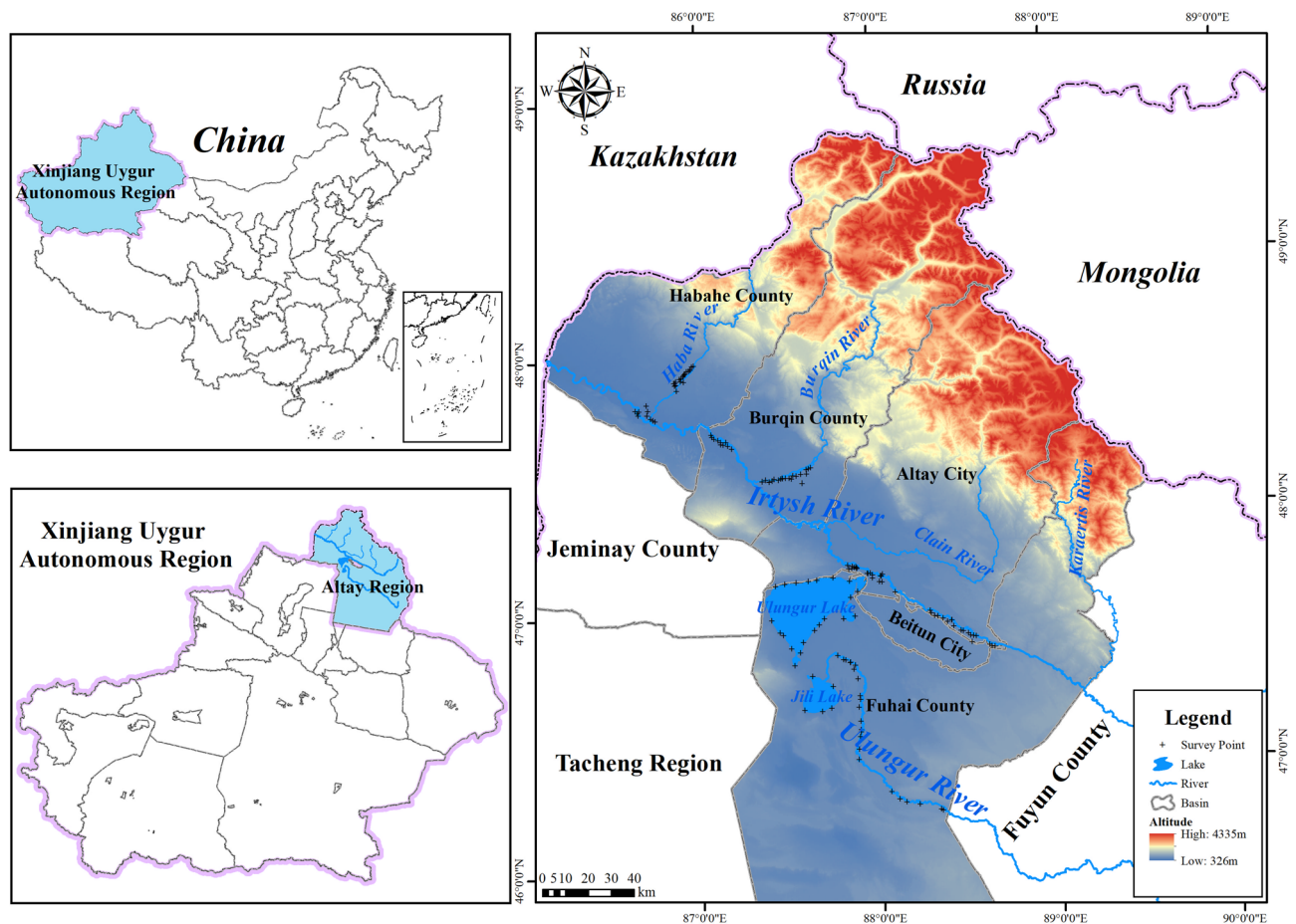


**Fig. 5.** Some species are from river valleys in the Altay region (Xinjiang, China). **A** *Limonium gmelinii* (Willd.) Kuntze (Plumbaginaceae) **B** *Rhaponticum repens* (L.) Hidalgo (Asteraceae) **C** *Typha orientalis* C.Presl (Typhaceae) **D** *Elaeagnus oxycarpa* Schltdl. (Elaeagnaceae) **E** *Sophora alopecuroides* L. (Fabaceae) **F** *Artemisia frigida* Willd. (Asteraceae). (photographed by Dr. Zhixi Fu).



**Fig. 6.** Some species are from river valleys in the Altay region (Xinjiang, China). **A** *Caragana halodendron* (Pall.) Dum.Cours. (Fabaceae) **B** *Peganum harmala* L. (Nitrariaceae) **C** *Ephedra przewalskii* Stapf (Ephedraceae) **D** *Nitraria sibirica* Pall. (Nitrariaceae) **E** *Zygophyllum pterocarpum* Bunge (Zygophyllaceae) **F** *Echinops ritro* L. (Asteraceae). (Photographed by Dr. Zhixi Fu).





**Fig. 7.** Location of the river valleys in the Altay region (Xinjiang, China).

## Data availability

The datasets used during the current study available from the corresponding author on reasonable request.

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## Author contributions

M.Z., X.C., X.Z. and T.Q. compiled the data and organized the data structure, Y.Z. wrote the manuscript, Z.F. and Y.Z. revised the manuscript, Z.F., Q.Y., H.Z. and J.W. were involved in the fieldwork. All authors have read and approved the final manuscript.

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## Declarations

## Competing interests

The authors declare no competing interests.

## Additional information

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