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Research Article

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The Altai Mountains of central Asia are biologically rich and comprise a wide diversity of ecosystems and lineages, including numerous endemic vascular plant species. Here we provide an updated checklist of the endemic vascular flora of the Altai Mountains with more taxa and higher geographic resolution than previously reported, as well as first molecular data and specimen images for many of these species. This flora is now known to contain 321 endemic species distributed in 34 families, many of which are narrowly restricted to one subregion of the Altai. The Fabaceae has given rise to the most endemic species in the Altai (74 spp.), and most of this diversity is found in the large and ecologically important genera *Astragalus* and *Oxytropis*. Approximately 60% of the endemic flora was imaged and successfully barcoded with at least one of three common DNA barcoding loci, and a phylogenetic tree based upon these loci is also presented to display the evolutionary breadth of endemism in the Altai. The distribution of each endemic species is presented in terms of a standard geographic subdivision of the Altai region, with general conservation priorities discussed based on areas currently afforded protected status.

Key words: Altai Mountain Country, biodiversity hotspot, conservation, DNA barcodes, endemic species

Introduction

Biodiversity loss is one of the greatest challenges being faced currently across lineages on Earth, as a high extinction rate has become a contemporary reality (Dirzo & Raven, 2003; Chase et al., 2020). Biodiversity conservation is difficult because it is often viewed as in conflict with local economic and cultural interests (Young et al., 2007). However, better conservation of unique ecosystems cannot be infinitely delayed, as biodiversity is decreasing so rapidly that stringent measures

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for its conservation are already late (Raven & Wilson, 1992; Kemppinen et al., 2020). The imperatives to conserve plant biodiversity specifically are multiple. Healthy, diverse plant communities maintain ecosystem services such as provisions for herbivores (and therefore higher trophic levels), clean water, air and soils, a more moderate climate, and many other important processes that sustain life (Pimm et al., 2014; Dee et al., 2019). Plant biodiversity remains a potential source of novel human benefits, and the discovery of new taxa, as well as greater study of known taxa, continues to expand the known list of food and medicinal plants as well as those of other uses (e.g. sources of raw materials and of genetic diversity to improve crop quality). Yet, our ability to detail such economic uses and ecosystem services is dependent on the maintenance of pre-industrial stocks of biodiversity (González-García et al., 2022). Habitat destruction of these stocks continuously threatens future study into uses and services of biological diversity, as well as more academic inquiries.

Endemic species, those restricted in their distribution to a relatively small geographic area, are the most vulnerable to extinction (Chichorro et al., 2019). Their comparatively restricted ranges make them more vulnerable to stochastic and anthropogenic disturbance events such as agricultural clearing and livestock grazing, touristic development, extractive industry, climatic changes, catastrophic storms, displacement by invasive species, or multiple factors in combination. For this reason, endemics are therefore some of the most critical taxa to be monitored for demographic changes. Based in part on high numbers of plant endemics and a high degree of preservation of the primary indigenous vegetation, 35 world biodiversity hotspots have been identified (Mittermeier et al., 2011), including the mountains of Central Asia (Mittermeier et al., 2011; Nobis et al., 2020; Nowak et al., 2011, 2020). Within Central Asia itself there are also local hotspots characterized by high numbers of endemic flora and fauna (CEPF (Critical Ecosystem Partnership Fund), 2017). One such area is the Altai Mountains, also known as the Altai Mountain Country (AMC). This region is subject to continued touristic and agricultural development, poaching, pollution, mining, reckless use of resources, and climate change, and it contains an endemic flora under particular threat from these and other disturbances.

The AMC is situated in the western part of the Altai-Sayan ecoregion of south-central Siberia. As outlined by Kamelin (2005), the AMC stretches between $\sim 45-54°N$ and $80-98°E$ and lies within portions of China, Kazakhstan, Mongolia and Russia (Fig. 1). The position of this region at the intersection of different floristic provinces, as well as its ecological and topographic diversity (with alpine, subalpine, steppe, desert and mixed forest components), has resulted in both a relatively high species richness and a high percentage of endemism (>10%) in the flora (Orme et al., 2005). The proportion of endemic species in these mountain regions is much greater than in the adjacent lowlands (Tang et al., 2006); for example, the plains flora of Novosibirsk and Tomsk Oblast' directly north of the AMC contains no more than two endemic species (Krasnoborov et al., 2000; Ebel et al. 2014). Basic characterization of plant endemism in the AMC was initially provided by Krylov (1905), in which he estimated endemics to comprise about 9% of the flora. The botanical diversity of the AMC is not yet fully enumerated but is currently estimated at $\sim$2800 vascular plant species and subspecies. Endemic and subendemic species together comprise about 10.3% of this region based on more recent estimates (e.g. Pyak et al., 2008; Vaganov & Shmakov, 2020). As a more specific example, the flora of the Russian state of Altai Krai in the AMC includes some 1888 native vascular plant species, of which 128 are endemic (8.5%: Silantieva, 2013). However, an updated checklist treating all endemic species of the AMC with fine geographic resolution remains lacking.

The AMC flora is one of the richest among the Asian parts of Russia, exceeded only by the richness of the Ussuri (Pacific area of the Russian Far East) floristic region (Malyshev et al., 2000). The endemism of the flora of Russian Altai has been described previously (Artemov et al., 2007; Pyak et al., 2008), but since then, new species have been reported from the AMC (e.g. Chkalov, 2014; Nosov et al., 2015; Erst et al., 2017; Oyuntsetseg et al., 2017; Pyak & Pyak, 2019; Ivaschenko, 2005; Baasanmunkh et al., 2021). The distributions of endemic plant species in Mongolian, Kazakhstani and Chinese parts of Altai have not been previously described. In addition, the geographic distributions of endemic species in the AMC remain only coarsely described, precluding better targeted and more accurate conservation measures. Understanding the geographic and taxonomic extent of endemic species in the AMC is thus of high priority. Another important approach towards rare species conservation is DNA barcoding (Vargas et al., 2009; Trivedi et al., 2016), which has also been useful in taxonomy (Vargas et al., 2012; Ali et al., 2014). One impediment to species inventory and management may be correct identification, as conventional morphology-based assessment is subject to several caveats and is sometimes of exceeding difficulty to non-specialists. DNA barcoding can be a useful tool to quickly and accurately identify species and has the potential to prompt the discovery of new species. A DNA barcode from a specimen of unknown identification can be compared with a barcode library with reference sequences derived from known specimens identified by taxonomic experts. Given the above, it is important to obtain DNA

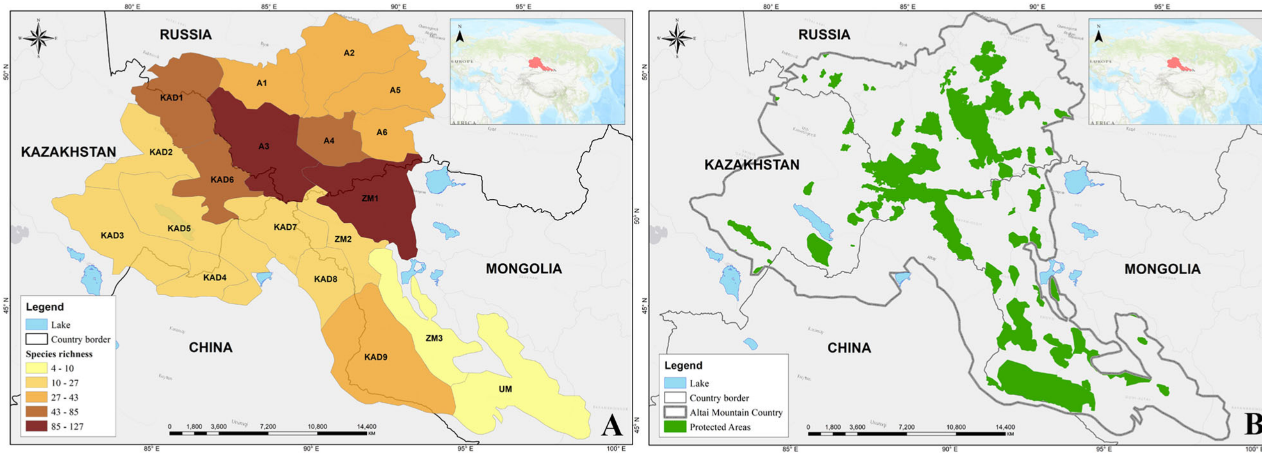

Fig. 1. Scheme of botanical–geographic subdivisions of the AMC (adapted from Kamelin, 2005 and Olonova et al., 2010) (left), with currently protected areas overlaid onto the region (right). A – Altai province (regions: A1 – Northern Altai, A2 – North-Eastern Altai, A3 – Central Altai, A4 – Tchulyshman, A5 – Abakan-Dzhebash, A6 – Khemchik). KAD – Altai-Dzungarian province (regions: KAD1 – North-Western Altai, KAD2 – Kalbinsky, KAD3 – Tarbagatai, KAD4 – Saur, KAD5 – Zaissan, KAD6 – Bukhtarma, KAD7 – Markakol-Kanas, KAD8 – Kara-Irtysh, KAD9 - Altai-Dzungarian). ZM, UM – Tuvinian-Mongolian province (regions: ZM1 – Chuya-Khobdo, ZM2 – Tsagan-Gol, ZM3 – Khobdo-Tonkhil; UM – South-Mongolian).

barcodes from the endemic vascular flora of the AMC for the first time, and to make it easier for non-specialists to identify such species.

Towards providing guidelines for better conserving the most unique elements of plant biodiversity in the Altai Mountains, our aims were: (1) to update the checklist of the endemic vascular flora of the AMC across its whole territory; (2) to present occurrence data of endemic species at a finer regional geographic resolution than previously; (3) towards their future protection, to examine patterns of distribution of endemics in the AMC and identify areas richest in endemics; and (4) to provide DNA barcodes to aid in identification of endemic species as well as place these barcodes in a phylogenetic context to display the evolutionary diversity of the endemic vascular flora, as well as to better clarify their taxonomic status. Results include an annotated list of endemic plants of the AMC based on a critical assessment of herbarium specimens and published floras, as well as the establishment of a new public database in BOLD that includes a growing number of specimen images and DNA barcodes of the endemic flora.

Materials and methods

Study area and its floristic-geographic zoning

The Altai Mountain Country is the highest mountain system in northern Asia, reaching a height of 4506 m asl at glaciated Mount Belukha. This region occupies a vast territory of about 550,000 square kilometres and is located where the borders of Russia, Mongolia, Kazakhstan and China converge (Fig. 1, created in ArcGIS 9). The climate of Altai varies largely depending on elevation, aspect and topography (Fig. 2), but is broadly characterized by its frigid winters, situated at the southern limit of Siberia. There is a humidity gradient across the AMC, with more humid areas found in the north-west and more arid areas found in the precipitation shadows to the south-east on the border of the Mongolian steppes and deserts. This gradient is attributable to moist air masses moving eastwards from the Atlantic, with the high ranges of Altai soaking in much of this remaining moisture before further movement eastwards. The AMC belongs to the Circumpolar Region of the Boreal Subkingdom (Kamelin, 1973, 2005) and is located on the border of different floristic provinces of the Boreal and Ancient Mediterranean floristic subkingdoms (Takhtajan, 1978). Although different authors have outlined the limits of the AMC in different ways, all of them have recognized the floristic frontier position of the region (Grubov, 1963; Kamelin, 1973, 1998, 2005; Revushkin, 1987, 1988; Wu Zh & Wu, 1996).

Takhtajan's (1978) classic scheme of the Earth's floristic zonation took into account the composition of endemic taxa (species, genera, families) to devise phytochorias of different ranks. In accordance with this scheme the AMC territory is subdivided into three basic regions (floristic provinces): the Boreal Mountainous South Siberian (Altai-West-Sayan floristic province), the Subboreal Steppe Mountainous South Altai-Dzungarian (Altai-Dzungarian province) and the Steppe-Desert

Fig. 2. Some ecological and topographic diversity within the study area. **A**, **B**. Steppe. **C**. Forest steppe. **D, E**. Mixed forest. **F–G**. Sparse coniferous forest near the treeline. **H**. Subalpine forest openings and meadows. **I**. Alpine tundra.

Central Asian (Tuvinian-Mongolian province). Kamelin (2005) later proposed a finer floristic zonation within the AMC based upon geography and vegetational composition. The Altai-West-Sayan floristic province includes subregions marked on Kamelin's scheme as A1–A6, the Altai-Dzungarian province includes subregions KAD1–KAD9, and the Tuvinian-Mongolian province includes subregions ZM1–ZM3 and UM (Fig. 1). Our approach further develops and discusses this floristic zonation of the AMC. The geographic ranges of species represented here are furthermore based upon the field experiences of the authors (Supplemental Figs 1–9).

In order to summarize endemic species composition similarities between AMC subregions and to discern patterns or anomalies therefrom, we conducted numerical analyses based on a presence or absence (1 or 0) matrix of each endemic in the recognized subregions (species distributions are also specified in the Checklist below). Similarities among subregions were calculated using Gower's general similarity coefficient cluster analysis in PAST (Hammer et al., 2001). Numbers of endemic species occurring in each Altai subregion within this scheme were compared to identify conservation priority hotspots, as protecting the areas with higher concentrations of endemic plants will have umbrella effects across other lineages occurring in the region.

Plant materials

Endemic and subendemic species distributions were compiled according to literature sources, physical herbarium collections, and we also utilized databases of digitized specimens, especially the collections of the Herbaria of Moscow State University (https://plant.depo.msu.ru/) and the Central Siberian Botanical Garden (http://herb.csbg.nsc.ru:8081). We use the term endemism to refer to those range-restricted taxa occurring only in a particular and narrow area (= within the AMC here) and found nowhere else; endemic species represent a unique component of each flora and indicate a flora's absolute differences from all other floras (Tolmachev, 1974; Kruckeberg & Rabinowitz, 1985; Baasanmunkh et al., 2020; Breman et al., 2020). Following other recent work (e.g. Aeschimann, 2004; Noroozi et al., 2016; Kliment et al.,

Table 1. Primer pairs used to amplify DNA barcode sequences.

Region	Primer	Sequence (5' to 3')	References
ITS	ITS_S2F	ATGCGATACTTGGTGTGAAT	Chen et al., 2010
	ITS4	TCCTCCGCTTATTGATATGC	White et al., 1990
matK	matK_xF	TAATTTACGATCAATTCATTC	Ford et al., 2009
	matK-MALPR1	ACAAGAAAGTCGAAGTAT	Dunning & Savolainen, 2010
	MatK-1RKIM-f	ACCCAGTCCATCTGGAAATCTTGGTTC	Kim, K.J. (unpublished)
rbcL	rbcLa-F	ATGTCACCACAAACAGAGACTAAAGC	Levin et al., 2003
	rbcLa-R	GTAAAATCAAGTCCACCRCG	Kress & Erickson, 2007

2016; Breman et al., 2020), we define subendemics as taxa with limited occurrences in the areas adjacent to the one of reference (= the AMC here). Subendemics of the AMC are included in our checklist and therefore may describe taxa, e.g. also peripherally occurring in the Sayan Mountains, or on adjacent steppes or other lowlands, but which primarily occur only in the AMC.

The list of endemic plant species of the AMC was initially informed by the following resources: *Red Book of Altaiskiy Krai* (Silantieva et al., 2016), *Red Book of Altai Republic* (Maneev et al., 2017), *Red Data Book of Tuva Republic* (Ondar et al., 2019), *Red Book of Khakasia Republic* (Krasnoborov et al., 2012), *Red Data Book of Kazakh SSR* (Bykov et al., 1981), *Red Book of Russian Federation* (Ministry of Natural Resources and Environment of the Russian Federation et al., 2012), and the Biodiversity of Altai-Sayan Ecoregion Database of Plants and Fungi (Vaganov & Shmakov, 2020). The following floras and checklists further informed our compilation: *Flora of Western Siberia* (Krylov et al., 1927–1964), *Flora of Siberia* (Krasnoborov et al., 1987 – 2007), *Flora of China* (Wu et al., 1994–2005), *Flora of Kazakhstan* (Pavlov et al., 1956–1966), *Synopsis of the Flora of Outer Mongolia* (Gubanov, 1996), *Synopsis of the Flora of the Ukok Plateau* (Dyiachenko, 1995), *Key to Plants of Kemerovo Region* (Krasnoborov et al., 2001), *Flora of the Vascular Plants of the West Altai Nature Reserve* (Kotukhov et al., 2002), Checklist of vascular plants of Kazakhstan Altai (Kotukhov, 2005), *Key to Plants of the Tuva Republic* (Shaulo et al., 2007), *Synopsis of the Flora of Siberia: Vascular Plants* (Malyshev et al., 2005), *Criteria for Choosing the Key Botanical Territories within Altai-Sayan Ecoregion* (Artemov et al., 2007), *Endemic Plants of the AMC* (Pyak et al., 2008), *Vergleichende Chorologie der zentraleuropäischen Flora* (Meusel et al., 1965), *Flora of Mongolia: annotated checklist of native vascular plants* (Baasanmunkh et al., 2022) as well as the *Atlas of North European Vascular Plants North of the Tropic of Cancer* (Hultén, 1986). Relevant taxonomic revisions and other specialized works were additionally consulted, namely Tzvelev (1976), Yakovlev et al. (1996), Shmakov (1999), Kosachev (2003), Kotukhov (2003), Ivashchenko (2005), Baikov (2007), Erst (2007), Smirnov (2007), Nobis (2014) and Nobis and Gudkova (2016). Herbarium materials (including collections made by the authors and affiliates since 1973) housed at ALTB, COLO, E, HAL, KRA, LE, MHA, MW, NS, NSK, PE, SSBG, TK and UBU were studied to better root distributions in physical voucher specimens (herbarium acronyms follow Thiers, continuously updated). The vast majority of collections from the AMC are not digitized and therefore not integrated into more global databases such as GBIF, precluding their efficacy in contributing to our study. Flowering plant family concepts follow the current taxonomy recognized by the Angiosperm Phylogeny Group (APG IV, 2016).

A total of 190 herbarium accessions were imaged and databased representing two phyla, three classes, 17 orders and 190 species in 28 families. This included 99 extant specimens housed at ALTB, NS, NSK and TK as well as another 91 specimens representing freshly collected material obtained from field trips in 2014–2016 by many of the authors. Leaf material from these latter was immediately preserved in silica gel at the time of collection. All digitized information, along with a specimen image (when possible), was uploaded to BOLD (www.boldsystems.org; Ratnasingham & Hebert, 2007; project name: “Endem” within the “Public Data” portal).

DNA extraction, PCR and sequencing

Extractions of DNA, PCR amplification and DNA sequencing were conducted on leaf tissue from the 190 specimens above at the Canadian Centre for DNA Barcoding (CCDB) at the University of Guelph. We attempted to sequence three standard barcode regions from each specimen: *matK*, *rbcL* and ITS2 (see Table 1 for primers). The cycle sequencing reaction and subsequent clean-up employed standard CCDB protocols (Ivanova et al., 2005), with products analysed on an ABI 3730xl capillary sequencer (Applied Biosystems, USA). Successful sequences were uploaded to the barcode library of the *Endemic Plants of Altai* project on BOLD. Sequence alignments were conducted using the Kalign algorithm (Lassmann & Sonnhammer, 2005) with the default alignment settings in the BOLD workbench, and these were then checked manually in SeaView (Galtier et al., 1996).

Statistical and phylogenetic analyses

The BLAST search function (https://blast.ncbi.nlm.nih.gov/Blast.cgi) was used to assess species and generic identification success for all newly obtained sequences. A successful identification was considered achieved if both compared sequences were from the same genus (or the same species, in fewer instances), otherwise, mismatched sequences were considered failures (Maloukh et al., 2017). TaxonDNA (Meier et al., 2006) was used to further test the accuracy of species assignments. The best match (BM) and the best close match (BCM) were taken into account, as were the formation of groups determined by similar sequences (by thresholds of 1% and 0.5%) for each sequenced region evaluated.

We concatenated all loci for phylogenetic analyses. The Amaryllidaceae was specified as the outgroup for analyses due to differential sequence success (APG IV, 2016; see Results below). The appropriate evolutionary models for our sequences were calculated in jModelTest 2.1.1 (Darriba et al., 2012). The best models were then selected for partitions using the Akaike Information Criterion (Akaike, 1974): TVM + I + G for *rbcL* and *matK*, and GTR + I + G for ITS2. Phylogenetic analyses were conducted using maximum likelihood (ML) and Bayesian inference (BI) methods in RAxML version 7.7.1 (http://embnet.vital-it.ch/raxml-bb/; Kozlov et al., 2019) and MrBayes 3.1.2 (Huelsenbeck & Ronquist, 2001), respectively. For BI, four runs of four Markov chains were carried out for 3 million generations, sampling every 100 generations for a total of 30,000 samples. Convergence of chains was assessed, the first 7500 samples (25%) were discarded as burn-in, and stationarity was determined according to the 'sump' plot. Convergence of the stationary distribution was assessed by ESS values (>200) in Tracer v.1.7.1 (Rambaut et al., 2018). The robustness of the ML trees was estimated by bootstrap percentages (BP) and by posterior probabilities (PP) for BI, and BP <50% and PP <0.95 were considered poor support.

Trees were visualized in FigTree v1.4.4 (Rambaut, 2009). Sequence composition was calculated using PAUP 4.0b10 (Swofford, 2002).

Results

Revised checklist and distributions

A total of 321 endemic vascular plant species belonging to 34 families are recognized here as occurring in the Altai Mountain Country (see Checklist below). The majority of these are flowering plants (318 spp. in 32 families), with an additional three endemic fern species in two families. The Fabaceae contains the most endemic species in the AMC, with 74 spp. recognized.

Table 2. Genera containing the most endemic species in the AMC.

Astragalus	37
Oxytropis	32
Delphinium	14
Elymus	14
Potentilla	13
Alchemilla	11
Taraxacum	10

Nearly all of these species are contained in the diverse and widespread northern temperate genera *Astragalus* and *Oxytropis* (Table 2), with 37 and 32 spp., respectively. The next most speciose genera are *Alchemilla*, *Delphinium*, *Elymus*, *Potentilla* and *Taraxacum*, with 10 – 14 endemic species in the AMC each (Table 2).

The number of endemic species in particular regions and especially subregions of the AMC is highly variable. This is reflected in the cluster analysis, in which particular areas are more similar to each other in terms of the number of endemics rather than their geographic or ecological similarity. Notably, the subregions ZM1, KAD6 and A3 contain the greatest numbers of endemic species, with over 100 in each of them (Fig. 3). The KAD1, A1, A4 and A6 subregions are also of great conservation importance, containing over 50 endemic species each (Figs 3, 4). In contrast, the UM, ZM3 and KAD8 subregions are most similar in having the fewest numbers of endemics (2, 10 and 14, respectively; Fig. 3).

Sequence recovery for three barcode regions

Locus amplification success varied, likely due to many sampled tissues being from older herbarium specimens (oldest: *Astragalus veresczaginii* from 1925). New molecular data totalling 458 sequences were successfully generated and deposited in GenBank. Of the 190 specimens from 190 species and 28 families, sequence recoveries were 168 (88.4%), 154 (81.0%) and 136 (71.5%) for *rbcL*, ITS2 and *matK*, respectively (Table 3). The *rbcL* dataset lacked two families out of the 28 (Linaceae, Violaceae), the ITS2 dataset lacked a different two families (Cystopteridaceae, Iridaceae) and the *matK* dataset lacked six families (Amaranthaceae, Caryophyllaceae, Crassulaceae, Cystopteridaceae, Thymelaeaceae and Violaceae). Problems with amplification were observed mainly in older herbarium samples (Kuzmina et al., 2017).

The length of the ITS2 region (with small parts of the 5.8S and 26S ribosomal subunit genes flanking ITS2) in the dataset ranged from 176 bp in *Thymus schischkinii* to 375 bp in *Papaver kuvajevii*, with a mean length of

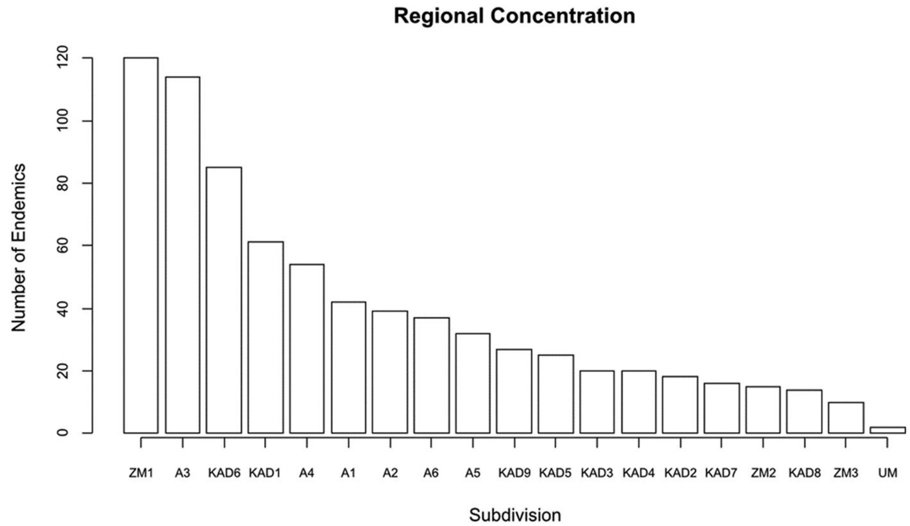

Fig. 3. The number of endemic species occurring in each subregion of the AMC. The most endemic diversity is clustered in the most steeply mountainous central regions of the AMC, in the vast borderlands of the four constituent countries.

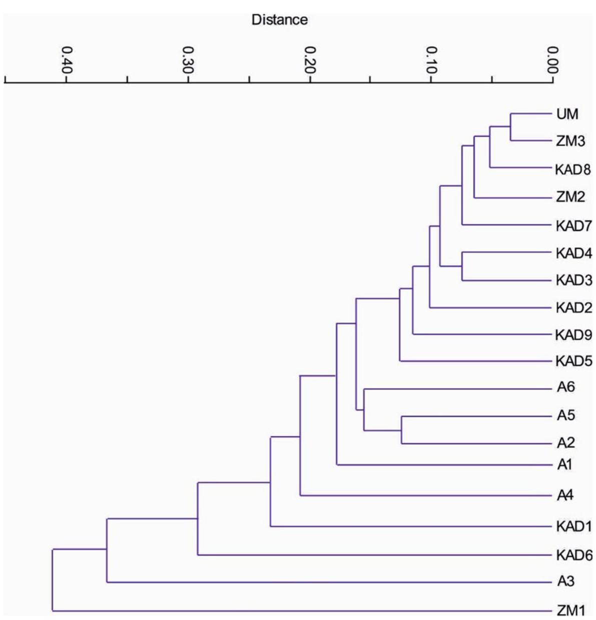

Fig. 4. Distance-based similarities of particular AMC subregions based on presence or absence of endemic species as implemented in PAST.

327.1 bp (±36.6) and a GC content of 58% (±4.2). As a non-coding region, ITS2 varied significantly across families, showing very few areas of primary sequence conservatism. Therefore, identification of positional homology in spacers was difficult. All sequences (except 36) of the partial *rbcL* gene were 553 bp long (mean length of 545.2 bp (±27.7) and had a GC content of 43.4% (±1.1)). The partial *matK* gene had a mean length of 727.9 bp (±96.9) and a GC content of 32.6% (±2.0).

Species resolution and phylogenetic analyses

The newly generated sequences were matched against reference sequences in BLAST. On the species level, identification success for both *rbcL* and *matK* was over two times lower than for ITS2, with correct identification percentages at 2.4%, 2.2% and 5.8% respectively. On the genus level, identification success for all regions was relatively low (80.4% – *rbcL*; 94.9% – *matK*; 89.7% – ITS2). The correct identification of species by best match or best close match options with Taxon DNA failed for all regions (identification success was 0%; Table 4). These analyses showed that the *rbcL* region yielded the highest rate for the ambiguous identification of species (best match: 47.61%; best close match: 47.02%; Table 4).

To evaluate the efficiency of barcode regions to produce specific clusters of species, we used the ‘cluster’ function of TaxonDNA at two different thresholds, 1% and 0.5%. With a threshold of 1%, the ITS2 region and the concatenated dataset worked best by producing 90 and 84 clusters, and 71 and 76 of those clusters included only one species for each analysis (Table 5). With a threshold of 0.5%, the ITS2 region and the concatenated dataset also produced the maximum number of clusters (107 and 90), with only one species in 91 and 82 of those clusters, respectively (Table 5).

The phylogenetic analysis included 109 sequences (= species) in 46 genera and 20 families with a concatenated length of 2049 characters (Table 6). Families formed clades with moderate to high bootstrap support, but topology between major clades was still not fully resolved in these analyses (Fig. 5). *Papaver* and *Corydalis* (Papaveraceae) were grouped with

Table 3. Sequencing success of loci sorted by family.

Family	Total # species	% of sequencing success (No. of species)		
		matK	***rbcL***	**ITS2**
Amaranthaceae	2	0 (0)	50 (1)	100 (2)
Amaryllidaceae	4	50 (2)	50 (2)	50 (2)
Apiaceae	2	100 (2)	100 (2)	100 (2)
Asteraceae	29	100 (29)	93.1 (27)	93.1 (27)
Boraginaceae	6	16.6 (1)	16.6 (1)	16.6 (1)
Brassicaceae	8	25 (2)	75 (6)	100 (8)
Caryophyllaceae	8	0 (0)	100 (8)	100 (8)
Crassulaceae	2	0 (0)	100 (2)	100 (2)
Cystopteridaceae	7	0 (0)	100 (7)	0 (0)
Euphorbiaceae	5	60 (3)	100 (5)	80 (4)
Fabaceae	45	100 (45)	82.2 (37)	100 (45)
Gentianaceae	2	100 (2)	100 (2)	100 (2)
Geraniaceae	2	50 (1)	100 (2)	100 (2)
Iridaceae	1	100 (1)	100 (1)	0 (0)
Lamiaceae	10	60 (6)	100 (10)	50 (5)
Linaceae	1	100 (1)	0 (0)	100 (1)
Orobanchaceae	5	80 (4)	100 (5)	100 (5)
Papaveraceae	5	100 (5)	100 (5)	60 (3)
Plantaginaceae	3	100 (3)	100 (3)	66.6 (2)
Plumbaginaceae	1	100 (1)	100 (1)	100 (1)
Poaceae	1	100 (1)	100 (1)	100 (1)
Ranunculaceae	16	37.5 (6)	100 (16)	62.5 (10)
Rosaceae	15	93.3 (14)	100 (15)	73.3 (11)
Rubiaceae	3	100 (3)	100 (3)	100 (3)
Saxifragaceae	2	100 (2)	100 (2)	100 (2)
Scrophulariaceae	2	100 (2)	100 (2)	100 (2)
Thymelaeaceae	2	0 (0)	100 (2)	100 (2)
Violaceae	1	0 (0)	0 (0)	100 (1)
Total	**190**	**71.5 (136)**	**88.4 (168)**	**81.0 (154)**

Table 4. Identification success based on the 'best match' and 'best close match' functions of TaxonDNA.

Barcode locus	Total number of sequences	Best match			Best close match			
		Correct (%)	**Ambiguous (%)**	**Incorrect (%)**	**Correct (%)**	**Ambiguous (%)**	**Incorrect (%)**	**Sequences without any match closer than 5.0%**
rbcL	168	0	47.61	52.38	0	47.02	50.59	2.38
matK	136	0	37.5	62.5	0	35.30	52.94	11.76
ITS2	154	0	20.12	79.86	0	16.88	62.98	20.12
Combined dataset	109	0	9.17	90.82	0	8.25	66.97	24.77

Ranunculus schmakovii (Ranunculaceae) here, and *Saussurea* (Asteraceae) remained unresolved.

Discussion

Barcoding success and utility

DNA barcoding has yielded important revelations of practical significance to human health, society, systematics and nature conservation (e.g. Lowenstein et al., 2009, 2010; Vargas et al., 2009, 2012; Ali et al., 2014; Kress, 2017; Trivedi et al., 2016; He et al., 2019). DNA barcoding has also been previously used to help inform endemic biodiversity checklist efforts (e.g. Lowenstein et al., 2011; Kang et al., 2017; Kress, 2017), and our study represents a geographically unique contribution to such work. We have provided a DNA barcode library for over half of the endemic plants of the AMC, and all DNA markers used were at least partially useful for generic- and species-level identification. However, there are shortfalls to the DNA barcoding approach utilized here, and this approach is nearly useless in some

Table 5. Cluster analysis implemented in TaxonDNA based on barcode regions.

	At 1% threshold				At 0.5% threshold			
Barcode locus	No. of clusters	% of clusters with threshold violation	Largest pairwise distance (%)	Clusters with only one species	No. of clusters	% of clusters with threshold violation	Largest pairwise distance (%)	Clusters with only one species
rbcL	59	6.77	2.36	32	79	2.53	1.15	56
matK	58	5.17	2.3	41	68	5.88	1	50
ITS2	90	3.33	8.11	71	107	2.8	0.82	91
Combined dataset	84	3.57	1.17	76	90	1.11	1.07	82

Table 6. DNA polymorphism data for the four generated sequence datasets.

Region	*rbcL*	*matK*	ITS2	*matK*+*rbcL*+ITS2
Number of samples sequenced	168	136	154	109
Aligned sequence length (nt)	553	915	581	2049
Monomorphic sites	360	303	237	900
Polymorphic sites	193	612	344	1149
Parsimony-uninformative variable characters	28	80	60	168
Parsimony-informative sites	165	532	284	981

systems (Stallman et al., 2019). Although the foci of our study will eventually be replaced with next-generation sequencing approaches (Taylor & Harris, 2012; Kress, 2017; Shneyer & Rodionov, 2019), the latter remain very expensive for widespread barcoding and are not yet useful for rapid sequence-based identification of components of any flora or fauna.

Our approach has nonetheless generated new data to help better elucidate the diversity, distribution and ecology of southern Siberian endemics, including herbarium specimen images and DNA barcodes based on *rbcL*, *matK* and ITS2 markers for over half of the endemic AMC flora, as well as voucher-based finer geographic resolution of the extent of the endemic flora. The revised checklist of endemic plants of the AMC will contribute towards scientifically sound environmental management in the region. Our work also allows for further investigation of patterns of floristic composition, biogeography and other features of the florogenesis of the AMC and areas genetically related to it. Our databases thus significantly supplement and summarize existing data on endemic plants of the AMC, allow for the formation of new hypotheses regarding their biology and origin, and will further inform investigations by environmental organizations working to protect the region's biodiversity. The data can further be used in genetic analyses that seek to, for example, identify biological objects in legal cases, identify species causing poisoning or illness and for treatment of which it is necessary to determine their taxonomic identities, substitute a product for a different one, generate new horticultural materials and other raw materials (especially of medicinal value) and to help identify crop weeds.

Endemic species discrimination

The AMC contains 321 known endemic and subendemic species, of which 190 species belonging to 28 families are represented by molecular data here. Not all studied species sequenced successfully, probably due to amplification failure from poor DNA quality or poor primer annealing (Kress & Erickson, 2007; Casiraghi et al., 2010; Roy et al., 2010; Hosein et al., 2017). In our dataset, the *rbcL* region was characterized by the highest level of sequencing success (88.4%) and the lowest level of genus identification success (80.4%) of studied genera. Conversely, the *matK* region sequenced rather poorly (71.5%) but had the highest level of genus identification success (94.9%). The ITS region was of intermediate value, but it identified species better than the chloroplast regions (more than double of the latter, at 5.8% identification success). This is probably the result of the high representation of this locus in GenBank as the most popular phylogenetic inference and barcode region in many groups of plants (e.g. Baldwin et al., 1996; Mishra et al., 2017). The low number of species identified in BLAST also indicates the lack of strictly related sequences currently available for comparison.

The 'cluster' analysis in TaxonDNA was able to parse species. This function demonstrated that the ITS2 region gave the best result, producing a larger number of groups. A threshold value based on genetic distances usually varies from 1–3% (Meier et al., 2006; Collins & Cruickshank, 2013). The proportion of 'ambiguous' and 'incorrect' values oscillated largely when the threshold was changed in our datasets, so we set the appropriate threshold values at 5%. The identification analysis in

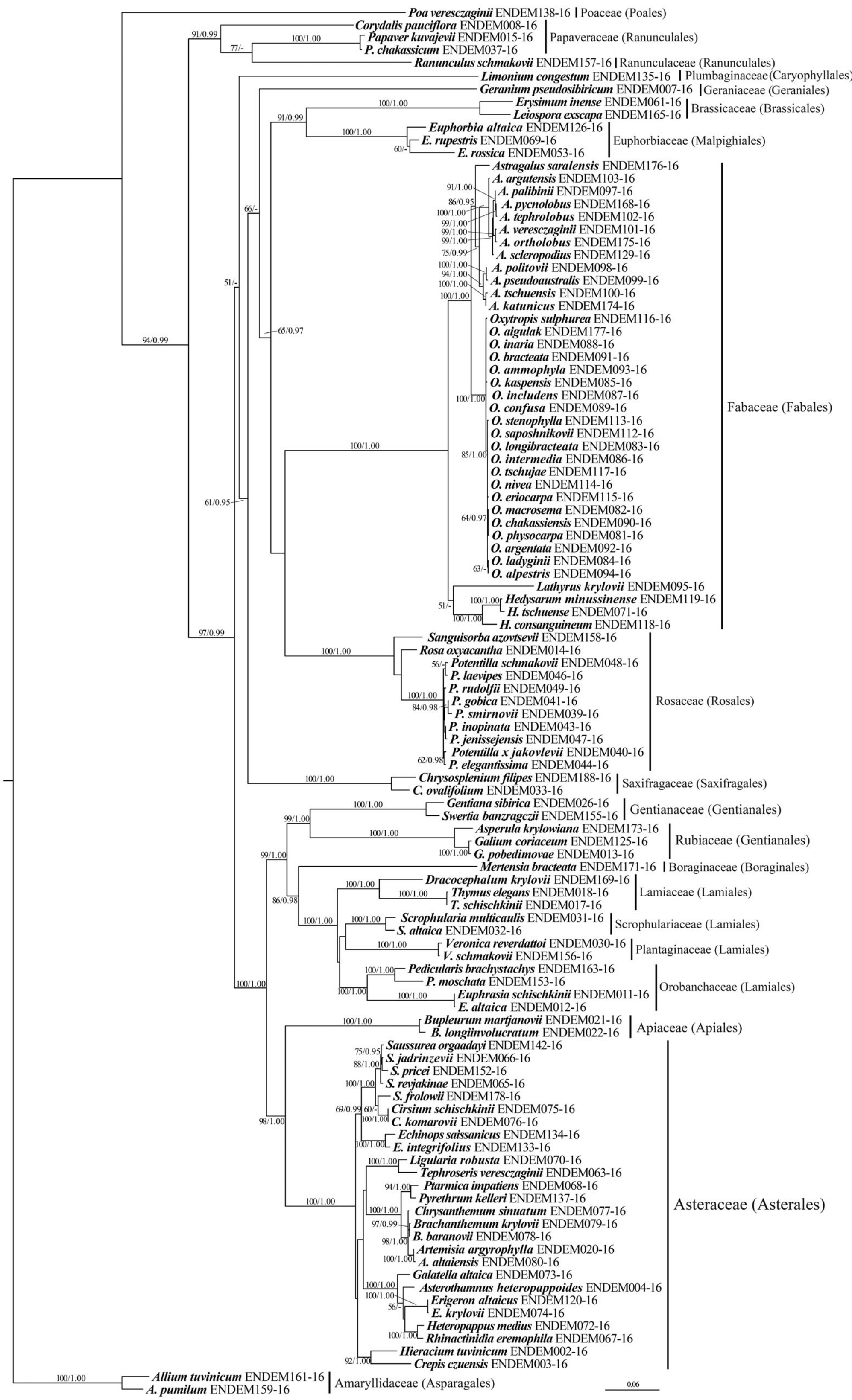

Fig. 5. ML phylogenetic tree showing evolutionary relationships of 109 taxa based on the combined *rbcL*+*matK*+ITS2 dataset. The BI analyses resulted in the same general topology. Support for ML and BI (BP $\geq$ 50% and PP $\geq$ 0.95, respectively) are given above or below the branches. Families are indicated to the right of the vertical line, with orders in brackets.

TaxonDNA showed that the *rbcL* region had the highest success rate for the ambiguous identification of species (best match: 47.61%; best close match: 47.02%). Surprisingly, concatenated datasets reduced identification success in TaxonDNA. Thus, the sequenced data from endemic plants of the AMC showed extremely low identification success for all regions on the genus level as estimated through BLAST search; absence of correct identification by 'best match' and 'best close match' functions in TaxonDNA; and high overall mean distances: 10.4% (±0.8) – *rbcL*, 23.4% (±1.1) – *matK* and 37.6% (±2.4) – ITS2 datasets. Such results are common for endemic species barcode assessments (Hebert et al., 2004; Hosein et al., 2017). The low percentages of identification success reported here highlight poor reference sequence library (i.e. GenBank) coverage of close relatives of the AMC endemic flora, as well as high genetic variation rates among barcode sequences even for congeners.

Phylogenetic analysis

Here, ML and BI approaches were used to depict and evaluate the broad evolutionary diversity of the endemic flora of the AMC. Concatenation produced the most robust tree, with all families recovered as monophyletic and with all genera except *Saussurea* (Asteraceae) joined into separate clades (Fig. 5). We obtained moderate resolution of tree topologies with high bootstrap support for this *rbcL*+*matK*+ITS2 dataset, and the topology of main plant orders in this tree was congruent with APG IV (2016). In a broad sense, resolution from the concatenation of barcode regions widely prevails over the results derived from individual regions (Filipowicz & Renner, 2012; Rosario et al., 2019). We recovered the same pattern here (phylogenetic results from individual loci not shown), hence, we presented only the combined dataset. Phylogenetics will have an increasingly valuable role in the conservation of the endemic flora of the AMC, particularly as relates to the south-western areas, where a complex evolutionary history has resulted in a diverse flora with both relictual and recently evolved components. Our work allows for scrutiny into additional areas of needed phylogenetic research in the flora, which include identification of unique evolutionary lineages, determination of phylogenetic value for conservation priority setting, and identifying phylogenetically independent comparisons between rare and widespread species.

Subregion similarities and conservation priorities

The AMC is a large territory at the junction of the borders of four nations and is home to hundreds of endemic vascular plant species. Knowledge about their taxonomic status, spatial distribution, and genetic diversity remains incomplete, but here, we have attempted to synthesize current data on the distributions of AMC endemics and to provide an initial framework for transboundary conservation activities. Of the 321 documented endemic taxa in the AMC, nearly one-third (at least 91 spp.) are potentially threatened or rare (Pyak et al., 2008). At the same time, most endemic species occur in only a few locations (and/or only one subregion) of the AMC (see Checklist), and further field studies are needed to better assess the population status of threatened species, as well as to seek new populations. Endemics tend to be most represented in the montane belt between 1000 and 2500 metres, and across elevations and subregions, they tend to be most represented on limestones, high alpine screes, barren sedimentary formations and alkali bottoms (Pyak et al., 2008), habitats that are often associated with narrow plant endemism elsewhere in the world (Kruckeberg, 1986; Sharples & Tripp, 2019a; Sharples, unpub. data).

The clusters corresponding to the three floristic provinces of the AMC (A, ZM, KAD) were quite well distinguished on the dendrogram of similarity of species composition, confirming the validity of distinction of these zones based in part upon endemism (Fig. 4). However, based on current knowledge, endemic plants are highly unevenly distributed across subregions of the AMC, ranging from four to 127 species represented in a given subregion. The richest subregions (A3, ZM1, KAD1, KAD6), characterized by the presence of a large number of particularly narrow local endemics, differ somewhat from the general pattern of provincial similarity recovered. In these areas, there is the greatest contrast of ecological conditions, greatest complexity of vegetation cover, and the steepest altitudinal gradients in the AMC. The three subregions with the highest endemic species richness (namely ZM1, A3 and KAD6 with 127, 115 and 85 spp., respectively) are particularly characterized by large mountains and high habitat heterogeneity, and are located around national borderlands. Subregions A3 and KAD6 contain both a high representation of deserts and steppes as well as vast alpine tundras, speckled with pockets of forest in between. Many of these diverse borderlands are already afforded some form of protected status (Fig. 1). These include large tracts of protected areas covering steep altitudinal gradients such as Tavan Bogd National Park (where the highest peak of Mongolia is found) and the regions around Mount Belukha, the highest peak of all Siberia. The highly diverse ZM1 area, however, is not yet well protected, given its unique status of harbouring the most endemics of any subregion in our study.

The clustering of some areas of the Altai-Dzhungarian province (KAD7, KAD8) and the Tuva-Mongolian province (ZM2, ZM3, UM) can be explained both by their geographic proximity (situated in the central and south-eastern part of Mongolian Altai as well as Chinese Altai) and by harbouring the lowest numbers of endemics. The areas ZM3 and UM were found to contain only four and 10 endemic species respectively, potentially due to a relative lack of data from these parts. A similar situation applies to the AMC of China, in which KAD4, KAD7 and KAD8 were also found to contain few endemic species. Russia and Mongolia currently protect the most area within the AMC: over half of the AMC territory falls in these nations, and about half of the AMC in these nations is protected. Kazakhstan currently protects only a small percentage of its territory in the AMC (Fig. 1). None of the AMC of China is currently granted special protections (Fig. 1), and given the relatively poorly known floristic character of this part of Altai, it is important to better document this region and to implement a conservation programme, if deemed necessary. However, our richness analyses only focused on large and general subregions of the AMC, and further studies are needed to form finer spatial distribution patterns based on georeferenced herbarium specimen records.

Currently, protected areas are still subject to economic usages, such as for traditional livestock grazing, medicinal plant collection, recreational tourism, and extractive industry. It will be critical to monitor what effect, if any, economic activities in the AMC may have upon population structure and demographics of the endemic flora, particularly in areas that are both richest in endemics and most vulnerable due to a comparative paucity of protected areas. Identifying areas that are not currently protected but which contain habitats of multiple endemic species is also critical work that can be initiated based in part upon the present study.

Conclusions

The study of endemic species and their protection in the AMC was traditionally carried out in different countries at different times, and their approaches and views as to the taxonomy and geographic distributions of species were consequently different. This led to disparate knowledge of priorities for conservation, as approaches to land management differ in each of the countries, and indeed, differ between districts within countries. Our research is based on a new synthesis of knowledge on the systematics of endemic species of the Altai Mountain Country, which makes it possible to expand our knowledge of the evolutionary processes associated with the origin of individual elements of the Altai flora. The creation of a specimen digitization database in BOLD Systems and at Tomsk University should begin to provide a basis for the unification, joint use and standardization of scientific data on plant species occurring in the Altai from different countries, especially endemic species. Making steps towards better conserving the flora of Altai will further enable studies for generations of ecologists and evolutionary biologists to come, especially those seeking to understand radiations in speciose lineages and factors that contribute to higher levels of endemism in certain areas over others.

Checklist of endemic vascular plant species of the Altai Mountain country

The following list is presented alphabetically by plant family, then alphabetically by genus and species therein. The first two families are of the non-flowering plants, followed by families of flowering plants. The known distribution of each species is given after the taxonomic authority, and representative herbarium specimen barcodes are then given in parentheses (when available). In some cases, more distribution areas are given than are available barcoded specimens; this reflects specimens known to the authors from Russian institutions whose specimens still lack barcodes and a formal accession number.

*Denotes an Altai subendemic (species with a centre of distribution in the AMC, but which also can be found in limited surrounding regions: definition from Pyak et al., 2008).

Aspleniaceae (1 sp.)

**Asplenium sajanense* Gudoschn. & Krasnob. A2 (IRKU001515, TK-000016, TK-000017, TK-000018, TK-000019, TK-000020, TK-003304).

Dryopteridaceae (2 spp.)

**Cystopteris altajensis* Gureeva. A1 – 6, KAD1 (TK-003052, NS0034314, NS0034315, ALTB1010000099, ALTB1010000102, ALTB1010000107, ALTB1010000166, ALTB1010000174, ALTB1010000225, ALTB1010000262, ALTB1010000280, ALTB1010000407, ALTB1010000413, ALTB1010000421, ALTB1010000424, ALTB1010000429, ALTB1010000432, ALTB1010000440, ALTB1010000448, ALTB1010000457, ALTB1010000537, ALTB1010000539, ALTB1010000545, ALTB1010000547, ALTB1010000609, ALTB1010000789, ALTB1010000802, ALTB1010000929, TK-000022, TK-000023, TK-000025, TK-000026, TK-

004048, TK-004245, TK-004246, TK-004247, TK-004248, TK-004249, TK-004250, TK-004251, TK-004252).

**Woodsia taigischensis* (Stepanov) Kuznetsov. A2 (TK-003305).

Amaranthaceae (6 spp.)

**Atriplex altaica* Sukhor. ZM1 (LE01019591, NS0000557, NS0010177, MW0591989, TK-003027).

**Chenopodium frutescens* C.A.Mey. ZM1 – ZM3 (NS0000558, NS0008937, NS0008936, NS0008922, NS0008921, NS0033951, MW0059183, MW0176065, MW0176066, MW0176067, MW0176068, MW0176070, MW0176071, MW0176073, MW0176064, MW0176069, MW0176072, MW0059187, MW0059189, MW0059184).

Corispermum altaicum Iljin. A1, A3, ZM1 (TK-001130, TK-001131, ALAV78246).

Corispermum erosum Iljin. ZM1 (TK-001132, TK-001133, TK-001134).

Salicornia altaica Lomon. ZM1 (LE01019669, MW0157335).

Suaeda tschujensis Lomon. & Freitag. ZM1, ZM3, UM (LE01019677, NS0001181, MW0176606, MW0176607, MW0947637, BRNU580448, BRNU623297, K000899733, TK-001198).

Amaryllidaceae (10 spp.)

**Allium austrosibiricum* N.Friesen. A3, A4, A6, ZM1 (NS0012349, NS0012348, NS0012347, NSK0029260, NSK0029259, NSK0029258, NSK0029257, NSK0029256, NSK0029266, NSK0029265, NSK0029264, NSK0029263, NSK0029262, NSK0029261, NS0014576, NS0014581, NS0015153, NS0015151, NS0015150, NS0015147, NS0015143, NS0015136, NS0015135, NS0015133, NS0015126, NS0015125, NS0015120, NS0015116, NS0015160, NS0015165, NS0015176, NS0015222, NS0015217, NS0015216, NS0015215, NS0015214, NS0015218, NS0015209, NS0015199, NS0015188, NS0015184, MW0173285, MW0173287, MW0173286, MW0045274, MW0045273, MW0165021, MW0045275, ALTB1100010309, ALTB1100008552, UBU137).

Allium azutavicum Kotukhov. KAD1, KAD2, KAD6 (ALTB1100000023).

**Allium bellulum* Prokhanov. A6, KAD6 (NS0007404, NSK0026307, NSK0026308, NSK0026309, NSK0026310, NSK0026311, NS0011490, NS0011489, NS0011488, NS0011487, NS0011486, NS0011485, NS0011484, NS0011483, NS0011482, NS0011511, NS0011510, NS0011508, NS0011507, NS0011506, NS0011505, NS0011504, NS0011503, NS0011502, NS0011501, NS0011500, NS0011499, NS0011498, NS0011497, NS0011496, NS0011495, NS0011494, NS0011493, NS0011492, NS0011491, NS0033161, MW0045269, MW0045266, MW0045270, MW0045271, MW0045263, MW0045267, MW0045268, MW0045262, MW0045264, MW0045265, MW0045261, MW0045272, UBU137, OSBU18878, B100240176, ALTB1100008707, ALTB1100008715).

Allium ivasczenkoae Kotukhov. KAD1 (ALTB1100000005).

Allium ledebourianum Schultes & Schultes f. A3, A4, KAD1, KAD6 (NS0012505, NS0012504, NS0012503, NS0012502, NS0012582, NS0012581, NS0012518, NS0012517, NS0012516, NS0012515, NS0012514, NS0012513, NS0012512, NS0012511, NS0012510, NS0012509, NS0012508, NS0012507, NS0012506, NSK0029527, NSK0029528, NSK0029529, NSK0029530, NSK0029531, NSK0029532, NSK0029533, NSK0029534, NSK0029535, NSK0029536, NSK0029537, NSK0029646, NSK0029648, NSK0029649, NSK0029650, NSK0029651, NSK0029652, NSK0029647, NS0014683, NS0015060, NS0015054, MW0045164, MW0045163, MW0045169, MW0045170, MW0045167, MW0045165, MW0045166, MW0045157, MW0045161, MW0045160, MW0045155, MW0045158, MW0045156, MW0045159, MW0045171, MW0045172, MW0045173, MW0045154, MW0045168, MW0045162, ALTB1100011129, ALTB1100011130, ALTB1100012484, ALTB1100011678, TK-003048).

**Allium pumilum* Vved. A3, A4, A6, ZM1 (NS0007024, NS0007403, NS0007402, NS0007401, NS0007400, NS0007399, NS0007398, NS0007397, NS0007396, NS0007395, NS0007394, NS0007392, NS0007393, NSK0026323, NSK0026322, NSK0026321, NSK0026320, NSK0026319, NSK0026325, NSK0026324, NSK0026318, NSK0026317, NSK0026316, NSK0026315, NSK0026327, NSK0026326, NSK0026313, NSK0026312, NSK0026314, NS0011525, NS0011524, NS0011523, NS0011522, NS0011521, NS0011520, NS0011519, NS0011518, NS0011526, NS0011516, NS0011515, NS0011514, NS0011513, NS0011512, NS0011517, NS0014428, NS0014441, NSK0008034, MW0173492, MW0044926, UBU1201, GFW258, OSBU18948, ALTB1100009735, ALTB1100009743, ALTB1100009751, ALTB1100009759, GAT0018279).

**Allium tuvinicum* (N.Friesen) N.Friesen. A2, A6, ZM1 (NS0014334, NS0014333, NS0014332, NS0015247, NS0015288, NS0015314, NS0015315, NS0015316, NS0015552, NS0015553, NS0015554, NS0015555, NS0015556, NS0015557, NS0015558, NS0015559, NS0015560, NS0015561, NS0015562, NS0015563, NS0015564, NS0015565, NS0015566, NS0015567, NS0015568, NS0015569, NS0015570, NS0015571, NS0015572, NS0015573, NS0015576, NS0015574, NS0015575, NS0015577, NS0015578,

NS0015579, NS0015580, NS0015581, NS0015582, NS0015583, NS0015585, NS0015586, NSK0061752, NSK0061753, NSK0061754, NSK0061755, NSK0061756, NSK0061757, NSK0061758, NSK0061759, NSK0061760, NSK0061761, NSK0061762, MW0044220, MW0044221, MW0044222, GFW439, HAL64845, GAT0020337, GAT0020338, ALTB1100012437, ALTB1100013043, GAT0020339, GAT0020342, GAT0020343).

**Allium tytthocephalum* Schult. & Schult. f. A3 – A6, ZM1 (BRNU569143, BRNU569068, BRNU569508, MW0167744, MW0044211, MW0044218, MW0045395, MW0173636, HAL104597, ALTB1100013051, ALTB1100013059, NS0012983, NS0012985, NS0014335, NS0014336, NS0014337, NS0014338, NS0014339, NS0014340, NS0015023, NS0015024, NS0015031, NS0015034, NS0015035, NS0015538, NS0015033, NS0015540, NS0015541, NS0015542, NS0015544, NS0015545, NS0015546, NS0015547, NS0015548, NS0015549, NS0015550, NS0015551, NSK0061763, NSK0061764, NSK0061765, NSK0061766, NSK0061768, NSK0061769, NSK0061770, NSK0061771, NSK0061772, NSK0061773, NSK0061774, NSK0061775, NSK0061776, NSK0061777).

Allium ubinicum Kotukhov. KAD1 (ALTB1100000119).

Allium vodopjanovae N.Friesen. KAD1 – KAD2 (NS0007008, NS0007011, NS0011509, NS0014348, NS0014349, NS0014350, NS0014351, NS0014352, NS0014353, NS0014355, NS0014357, NS0014358, NS0014359, NS0014360, NS0014361, NS0014362, NS0014363, NS0014364, NS0014365, NS0014366, NS0014367, NS0014368, NS0014369, NS0014370, NS0014371, NS0014372, NS0014373, NS0014374, NS0014375, NS0014376, NS0014377, NS0014390, NS0014388, NS0014387, NS0014386, NS0014385, NS0014384, NS0014383, NS0014382, NS0014381, NS0014380, NS0014378, NS0015537, NS0015536, NS0015535, NS0015719, NS0015718, NS0015717, NS0015716, NS0015715, NS0015714, NS0015713, NS0015712, NS0015711, NS0015710, NS0015709, NS0015708, NS0015707, NS0015706, NS0015705, NS0015704, NS0015703, NS0015702, NS0015600, NS0015599, NS0015598, NS0015597, NS0015596, NS0015594, NSK0061865, NSK0061866, NSK0062029, NSK0062028, NSK0062027, NSK0062026, NSK0062025, NSK0062024, NSK0062023, NSK0062022, NSK0062020, NSK0062019, NSK0062018, NSK0062017, NSK0062021, NSK0062016, NSK0062015, NSK0062030, NSK0062031, NSK0062032, NSK0062035, NSK0062034, NSK0062036, NSK0062037, NSK0062038, NSK0062039, NSK0062040, NSK0062041, NSK0062042, NSK0062043, NSK0062044, NSK0062045, NSK0062046, NSK0062047, NSK0062048, NSK0062049, NSK0062050, NSK0062051, NSK0062052, NSK0062053, NSK0062054, NSK0062055, NSK0062056, NSK0062057, NSK0062058, NSK0062059, NSK0062060, NSK0062061, NSK0062062, NSK0062063, NSK0062064, NSK0062065, NSK0062066, NSK0062079, NSK0062080, NSK0062081, NSK0062082, NSK0062083, NSK0062067, NSK0062068, NSK0062069, NSK0062077, NSK0062070, NSK0062078, NSK0062071, NSK0062072, NSK0062073, NSK0062074, NSK0062075, NSK0062076, NSK0062225, NSK0062226, NSK0000024, NSK0000013, NSK0000012, NSK0000014, NSK0000025, NSK0000026, MW0044159, KUZ009078, KUZ009010, KUZ009098, KUZ009096, KUZ009105, KUZ009095, KUZ009094, KUZ009083, KUZ009084, KUZ009087, KUZ009108, KUZ009090, KUZ009107, KUZ009080, KUZ009081, KUZ009106, KUZ009088, KUZ009086, KUZ009089, KUZ009091, KUZ009082, KUZ009085, KUZ009101, KUZ009102, KUZ009092, KUZ009093, KUZ009100, KUZ009079, KUZ009104, KUZ009103, KUZ009099, KUZ009097, MW0044151, MW0173639, MW0173641, MW0173642, MW0173643, MW0173644, MW0173638, MW0173640, MW0044156, MW0044148, MW0044150, MW0044137, MW0044155, MW0044147, MW0044157, MW0044154, MW0044153, MW0044146, MW0044145, MW0044141, MW0044139, MW0044149, MW0044133, MW0044135, MW0044134, MW0044142, MW0044140, MW0044138, MW0044136, MW0044152, MW0044144, MW0044143, MW0044158, FR0129927, FR0129928, FR0129929, BRNU580476, BRNU580478, BRNU580486, BRNU582094, BRNU623211, BRNU627446, ALTB1100009036, ALTB1100007854, ALTB1100009337, ALTB1100007998, ALTB1100008006 ALTB1100008438, ALTB1100011321, ALTB1100008077, ALTB1100010289, ALTB1100010557, ALTB1100012645).

Apiaceae (2 spp.)

Bupleurum longiinvolucratum Krylov. KAD1 (TK-000845, TK-003056, TK-003057, TK-003058, NS0000578).

**Bupleurum martjanovii* Krylov. A2, A4, A5 (TK-000847, TK-003059, TK-003060, TK-003061, TK-000848, TK-000847, TK-000849, NS0000579, NS0008269, NS0008270, NS0008271, NS0008272, NS0008273, NSK0026893, NSK0026894, NSK0026895, NSK0026896, NSK0026897, NSK0026903, NSK0026898, NSK0026899, NSK0026900, NSK0026901, NSK0026902, NS0008268, NS0008267, NS0008266, NS0008265, NS0008264, NS0008263, NS0008262, NS0008261, NS0008260, NS0008259, NS0008258, NS0008257, NS0011534, NS0011532, NS0011531, NS0011530,

NS0011539, NS0011538, NS0011537, NS0011536, NS0011535, NS0011533, NS0011550, NS0011549, NS0011548, NS0011547, NS0011546, NS0011545, NS0011544, NS0011543, NS0011542, NS0011541, NS0011540, MW0106498, MW0106494, MW0106496, MW0106497, MW0106500, MW0106502, MW0106505, MW0106495, MW0106504, MW0106499, MW0106501, MW0106503, BRNU576850, BRNU569415).

Asteraceae (43 spp.)

Ajania grubovii Muldashev. KAD9 (LE01017232, MW0192082, MW0192083, MW0192085, MW0192086, MW0192084).

Artemisia altaiensis Krasch. ZM1 (NS0007142, NS0007141, NS0007124, NS000053, MW0192281, MW0192282, MW0192283, MW0192284, MW0192285, MW0192285, MW0192287, MW0192288, MW0192289, MW0192290, MW0192291, MW0143087, MW0143090, MW0143091, MW0143092, MW0143093, MW0143086, MW0143088, MW0143089, BRNU623094, HAL100998, HAL100999, TK-003087, TK-003088, TK-003103).

Artemisia argyrophylla Ledeb. ZM1 (NS0007125, NS0000580, NS0009931, MW0142966, MW0142965, MW0142967, MW0142968, MW0142963, MW0142964, MW0192335, MW0192337, MW0192338, MW0192339, MW0192340, MW0192341, MW0192342, MW0192334, MW0192336, MW0142962, BRNU582478, TK-003086, TK-003085, TK-003083).

Artemisia kotuchovii Kupr. KAD6 (KUZ-KAZ11473, KUZ-KAZ11474, KUZ-KAZ11475).

**Asterothamnus heteropappoides* Novopokr. ZM1 (NS0000598, NS0010137, NS0010136, MW0146732, MW0146731, MW0146730, MW0191505, MW0191506, MW0191507, MW0191508, MW0191509, MW0191510, OSBU10218).

Brachanthemum baranovii (Krasch. & Poljakov) Krasch. A3 (NS0000535, NS0008176, NS0008175, NS0008174, NS0008173, O-V2263591).

Brachanthemum krylovii Serg. A3 (NS0000534, NS0000188, NS0008172, TK-003003).

Cancrinia krasnoborovii Khanm. ZM1 (NS0000171, NS0000170, NS0000169).

Centaurea kryloviana Serg. KAD2, KAD5, KAD6 (TK-001357, TK-001358, TK-001359, TK-003121, TK-003122, KUZ-KAZ11061).

**Chrysanthemum sinuatum* Ledeb. A1 – A3, A5, KAD1, ZM1 (NS0009145, NS0009144, NS0009113, NS0009114, NS0009115, NS0009116, NS0009117, NS0009143, NS0009142, NS0009141, NS0009140, NS0009139, NS0009138, NS0009137, NS0009136, NS0009135, NS0009134, NS0009112, NS0009111, NS0009110, NS0009109, NS0009108, NS0009107, NS0009106, NS0009105, NS0009104, NS0009103, NS0009102, NS0009101, NS0009100, NS0009099, NS0009098, NS0009097, NS0009096, NS0009095, NS0009094, NS0009093, NS0009087, NSK0027970, NSK0027971, NSK0027972, NSK0027973, NSK0027974, MW0143642, MW0192118, MW0192119, MW0143641, MW0143643, MW0143644, MW0143646, MW0143647, MW0143648, MW0143649, MW0143650, MW0143654, MW0143656, MW0143658, MW0143660, MW0143661, MW0143662, MW0143663, MW0143664, MW0192120, MW0192121, MW0192122, MW0192123, MW0143635, MW0143636, MW0143637, MW0143638, MW0143645, MW0143657, MW0143639, MW0143640, MW0143651, MW0143652, MW0143655, MW0143659, MW0143653, BRNU623046, B100274585, B100209781, B100341133).

**Cirsium komarovii* Schischk. (including *C. schischkinii* Serg.). A2 – A4, A6 (NS0007116, NS0000537, MW0150595, MW0150524, ALTB1100006311, ALTB1100006337, ALTB1100006416, ALTB1100006424, ALTB1100006529, ALTB1100006542, ALTB1100006637, ALTB1100006677, ALTB1100006687, ALTB1100006690, ALTB1100006709, ALTB1100006815, ALTB1100006851, ALTB1100006859, ALTB1100006867, ALTB1100006875, ALTB1100006883, ALTB1100006908, ALTB1100006916, ALTB1100007022, ALTB1100007038, ALTB1100007089, ALTB1100007104, ALTB1100007149, ALTB1100007157, ALTB1100007160, ALTB1100007183, ALTB1100007191, ALTB1100007221, ALTB1100007223, ALTB1100007255, ALTB1100007312, ALTB1100007319, ALTB1100007345, ALTB1100007429, ALTB1100007437, ALTB1100007439, ALTB1100007452, ALTB1100007531, ALTB1100007610, TK-003112, TK-003109, TK-003108, TK-003106, TK-003105, TK-003114).

Echinops integrifolius Kar. & Kir. KAD3, KAD4, KAD6 (MW0887563, MW0595149, MW0193700, MW0193701, MW0193702, MW0193703, MW0193704, MW0193705, MW0152087, MW0887561, MW0887562, HAL104782, HAL57311, UBU2786, TK-003004, TK-003126, TK-003131, TK-003132, KUZ-KAZ06365, KUZ-KAZ06366, KUZ-KAZ09742).

Echinops saissanicus (B.Keller) Bobrov. KAD5, KAD6 (MW0152059, TK-003008, TK-003137, TK-003134, TK-003133, KUZ-KAZ11476, KUZ-KAZ11477, KUZ-KAZ11478, KUZ-KAZ11479, KUZ-KAZ11480, KUZ-KAZ11481).

Erigeron altaicus M.Popov. A3, KAD1, KAD6 (NS0000539, MW0191621, MW0191620, MW0146261, MW0146262, MW0146259, MW0881941, MW0146260, MW0146263, BRNU582564, BRNU623061, BRNU623799, BRNU623800, TK-003151, TK-003150, TK-003148, TK-003155, TK-003152, TK-003143, TK-003145).

Galatella altaica Tzvelev. KAD8, ZM1 (NS0000540, MW0146649, MW0146648, BRNU582565, TK-003021, TK-003175, TK-003174, TK-003173, TK-003172, TK-003170).

**Heteropappus medius* (Krylov) Serg. A1, A3 (NS0000541, MW0133280, MW0133279, MW0133277, MW0133278, TK-003022, TK-003176).

**Hieracium tuvinicum* Krasnob. & Schaulo. A1, A2, A4 (NS0000600, NS0000274, NS0000275, NS0000276, NS0000277, NS0000278).

Ligularia robusta (Ledeb.) DC. A3 (NS0000543, MW0152234, MW0152235, ALTB1100006319, ALTB1100006353, ALTB1100006508, ALTB1100006676, ALTB1100007081, TK-003025).

**Ptarmica ledebouri* (Heimerl) Serg. A3 – A5 (ALTB1100006391, ALTB1100006399, ALTB1100006481, ALTB1100006525, ALTB1100006538, ALTB1100006549, ALTB1100006562, ALTB1100006625, ALTB1100006673, ALTB1100006681, ALTB1100006689, ALTB1100006752, ALTB1100006931, ALTB1100006939, ALTB1100007044, ALTB1100007097, ALTB1100007100, ALTB1100007108, ALTB1100007116, ALTB1100007425, ALTB1100007248, ALTB1100007369, ALTB1100007444, ALTB1100007490, ALTB1100007539, TK-003211, TK-003208, TK-003189, TK-003200, TK-003188, TK-003181, TK-003185).

Pyrethrum kelleri (Krylov & Plotn.) Krasch. KAD6 (TK-003010, KUZ-KAZ11482, KUZ-KAZ11483).

Pyrethrum krylovianum Krasch. A1 – A3, KAD1, KAD6 (MW0143403, MW0192226, MW0143401, MW0143402, TK-003217, TK-003216, TK-003215, TK-003213).

Rhaponticoides zaissanica Kupr., A.L.Ebel & Khrustaleva. KAD5 (TK-002341, TK-002342).

Saussurea ceterachifolia Lipsch. KAD9, ZM1 – ZM3 (NS0004018, MW0193829, MW0193830, MW0193831, MW0193832, MW0193833, HAL100921).

Saussurea chichaczevii Maneev & Krasnob. ZM1 (NS0000371, NS0000372).

**Saussurea frolowii* Ledeb. A1 – A6, KAD1, KAD3, KAD6 – KAD8 (NS0004013, MW0150078, MW0151653, MW0151654, MW0151655, MW0151656, MW0151657, MW0151658, MW0151651, MW0151652).

Saussurea jadrinzevii Krylov. A3 (NS0000373, NS0000546, MW0151614, TK-003024).

Saussurea orgaadayi Khanm. & Krasnob. A4, A6, KAD7 – KAD9, ZM1 – ZM3 (NS0000374, NS0000375, NS0000376, MW0193904, ALTB1100000099, UBU20180340, UBU20180341, TK-003251).

Saussurea revjakinae S.V.Smirnov. A3 (NS0000547).

Saussurea sajanensis Gudoschn. A5 (TK-001360, GFW45811, HAL47189, HAL58149, HAL57853, GFW44110).

**Saussurea serratuloides* Turcz. A3, KAD6 (LE01072427).

Scorzonera grubovii Lipsch. KAD9 (LE01024340, LE01024341, MW0194377, MW0194378).

Taraxacum aksaicum Schischk. ZM1 (TK-001362, NS0007128, NS0000548).

Taraxacum formosissimum Kirschner & Štěpánek. ZM1 (PRA).

Taraxacum junatovii Tzvelev. KAD9, UM, ZM2 (LE01024364, LE01024365, LE01024366, LE01024367, LE01024368, LE01024369, LE01024370).

Taraxacum krasnoborovii Krasnikov. ZM1.

Taraxacum krylovii Krasnikov. A3, ZM1 (NSK0071818).

Taraxacum lyratum (Ledeb.) DC. A4, KAD1, ZM1 (NS0000601, NS0001142, MW0149051, MW0149052, MW0149050, MW0149053).

Taraxacum niveum Kirschner & Štěpánek. A3 (ALTB1100014431, ALTB1100015834, ALTB1100015836).

Taraxacum smirnovii Ivanova. KAD9.

Taraxacum submacilentum Tzvelev. ZM1 (MW0595336).

Taraxacum ustamenum R. Doll. KAD2 (MW0194647).

Taraxacum ustkanensis Ivanova. A3.

Tephroseris veresczaginii (Schischk. & Serg.) Holub. A3, ZM1 (MW0152375, MW0152376, TK-003028).

Boraginaceae (15 spp.)

Anoplocaryum tenellum A.L.Ebel & Rudaya. ZM2 (NSK0000080, ALTB1100000041, TK-001914, TK-001915, TK-001916).

Anoplocaryum turczaninovii Krasnob. A6, ZM1 (NS0000096, NS0000097, NS0000098, NS0000099, NS0000095, NS0000447, MW0132936, MW0132937, TK-001917, TK-001918, TK-001919).

**Brunnera sibirica* Steven. A1 – A5 (MW0478737, MW0478736, MHA0067302, MHA0067304, MHA0067314, MHA0067301, MHA0067300, MHA0067309, MHA0067307, MHA0067299, MHA0067313, MW0132604, MW0132605, MW0478741, MW0132609, MW0478739, MW0478734, MW0478738, MW0478735, MHA0067297, MHA0067303, MHA0067305, MHA0067306, MHA0067308, MHA0067310, MHA0067311, MHA0067312, MW0132611, MW0132606, MW0132607, MW0132608, MW0132610, MW0478740, MW0478742, MW0567715, MW0164503).

Craniospermum canescens DC. ZM1 (MW0188419, HAL58062, HAL58125, OSBU10460).

Craniospermum subfloccosum Krylov. A3, KAD6 (TK-001364, TK-001365, TK-001366, TK-001367).

Eritrichium alpinum Ovczinnikova. A3 – A6, ZM1 (NS0000583, NS0000147, NS0000146, NSK0008428, NSK0008461, MW0132836).

Eritrichium kamelinii Ovczinnikova. A1 – A6, KAD1, KAD2, KAD5, ZM1 (NSK0000083, NSK0005737, NSK0005736, MW0132833, MW0132832, MW0132829, MW0132933, MW0132934, MW0132820, MW0132830, MW0132807, MW0132821, MW0132834, MW0132793, MW0132808, MW0132822, MW0132980, MW0132981, MW0132982, MW0132989, MW0132995).

**Eritrichium tuvinense* M.Popov. A6 (MW0950909, MW0950910, MW0132854, MW0132855, MW0132856, MW0132857, MW0132858).

Lappula krylovii Ovczinnikova, A.I.Pyak & A.L.Ebel. KAD5, ZM1 (NSK0000091, NSK0000090, TK-001958, TK-001964).

Lappula lipskyi M. Popov. KAD5, KAD6 (NSK0008185, NSK0008184, KUZ-KAZ10289).

Lappula zaissanica (Aralbaev) Aralbaev. KAD5 (NSK0005834, NSK0008741, NSK0008740).

Mertensia bracteata (Willd. ex Schultes) Kamelin. KAD1, KAD6 (TK-003327, TK-003334, TK-003335).

Mertensia meyeriana J.F.Macbr. KAD3, KAD4 (MW0876554, TK-004232, TK-004233, TK-004234, TK-004235, TK-004236, TK-004237, TK-004238, TK-004239, TK-0042240).

Mertensia tarbagataica B.Fedtsch. KAD3 (TK-004222, TK-004223, TK-004224, TK-004225, TK-004226, TK-004227, TK-004228, TK-004229, TK-004230, TK-004231).

Myosotis schmakovii O.D.Nikif. A3, A4, ZM1 (NSK0068730).

Brassicaceae (9 spp.)

**Dentaria sibirica* (O.E.Schulz) N.Busch. A1, A2, A5 (NS0000550, NS0009086, NS0009085, NS0009084, NS0009083, NS0009082, NS0009081, NS0009080, NS0009079, NS0009078, NSK0027981, NSK0027980, NSK0027982, MW0081086, MW0081085, MW0081087, ALTB1100005579, ALTB1100005587, ALTB1100006341, ALTB1100006357, ALTB1100006470, ALTB1100006612, ALTB1100006946, ALTB1100007154, ALTB1100007162, ALTB1100007233, ALTB1100007313, ALTB1100007351, ALTB1100007440, ALTB1100007478).

Draba sapozhnikovii A.L.Ebel. A3 (NSK0000435, TK-001351, TK-001352, TK-001353, TK-001354, TK-001355).

Erysimum inense N.Busch. A3 (NS0000551, TK-003030).

Erysimum kotuchovii D.A.German. KAD6 (MW0180266).

Erysimum ledebourii D.A.German. KAD1, KAD8 (MW0079060).

**Leiospora exscapa* (C.A.Mey.) Dvorák. ZM1 (MW0180533, MW0180534, MW0180535, MW0090885, MW0090886).

**Pachyneurum grandiflorum* (C.A.Mey.) Bunge. A3, A4, A6, KAD8, KAD9, ZM1 – ZM3 (NS0000595, NS0026012, MW0090877, MW0180521, MW0180525, MW0180526, MW0180527, MW0180528, MW0180529, MW0180530, MW0180531, MW0180532, MW0186366, MW0180517, MW0180518, MW0180519, MW0180520, MW0180522, MW0180523, MW0180524, MW0090880, MW0090882, MW0090878, MW0090879, MW0090881, GFW45546, HAL101284, HAL45541, OSBU10294, HAL130101, HAL120244, HAL57564, HAL10313, HAL10422, HAL57616, OSBU10288, OSBU10565, HAL129616).

Smelowskia altaica (Pobed.) Botsch. A3, ZM1 (NS0000552, MW0180029, MW0180030, MW0180031, MW0180032, TK-003017).

Sterigmostemum fuhaiense H.L.Yang. KAD5, KAD6 (TK-003037).

Campanulaceae (1 sp.)

**Adenophora golubinzevaeana* Reverd. A2, A5 (NY03501014).

Caryophyllaceae (8 spp.)

Dianthus mainensis Shaulo & Erst. A5 (NS0000553, NS0000165, NS0000164, NS0000163, NS0000162, NS0000161, NS0000160, NS0000159, NS0000158).

Eremogone mongolica (Schischk.) Ikonn. ZM1, ZM2 (NS0000555, MW0067153, TK-003002).

**Gypsophila sericea* (Ser.) Krylov. A3 – A5, KAD1, KAD2, KAD6, ZM1 (NS0000556, MW0064852, MW0064862, MW0064846, MW0064850, MW0177816, MW0064843, MW0064844, MW0064845, MW0064847, MW0064848, MW0064849, MW0064851, MW0064853, MW0064854, MW0064855, MW0064856, MW0064858, MW0064859, MW0064860, MW0064861, MW0064863, MW0064864, MW0064842, ALTB1100002965, ALTB1100003031, ALTB1100003033, ALTB1100003280, ALTB1100003281, ALTB1100003282, ALTB1100003283).

Mesostemma martjanovii (Krylov) Ikonn. A3, ZM1 (NS0000298, NS0010373, NS0010372, MW0592065, TK-003040, TK-003386, TK-003387). For evidence supporting the usage of the genus *Mesostemma* rather than *Stellaria* for this species, see Sharples and Tripp (2019b).

***Silene turgida* M.Bieb. ex Bunge. A1, A3, A4, A6, ZM1 (NS0000554, NSK0068340, NSK0068325, MW0065846, MW0065845, MW0065851, MW0065852, MW0065842, MW0065840, MW0065844, MW0065847, MW0065849, MW0065850, MW0065848, MW0065839, MW0065841, MW0065843, ALTB1100004441, ALTB1100004449, ALTB1100004475, ALTB1100004482, ALTB1100004483, ALTB1100004498, ALTB1100004490, ALTB1100004491, ALTB1100004506, ALTB1100004531, ALTB1100004540, ALTB1100004564, ALTB1100004572, ALTB1100004613, ALTB1100004629, ALTB1100004678, ALTB1100004741, ALTB1100004798, ALTB1100004881, ALTB1100004918, ALTB1100004942, ALTB1100005007, ALTB1100005015, ALTB1100005021, ALTB1100005023, ALTB1100005086, ALTB1100005087, ALTB1100005431, ALTB1100005439, ALTB1100005815, ALTB1100005831, ALTB1100005990, ALTB1100005901, ALTB1100006081, ALTB1100006089, ALTB1100006097, ALTB1100006110, ALTB1100006118).

Stellaria imbricata Bunge. ZM1 (MW0177109, MW0177110, MW0177108, OSBU10417, TK-003051).

Stellaria pulvinata Grubov. KAD8, KAD9, ZM1, ZM2 (NS0001246, MW0177171, MW0177172, MW0177173, MW0177174, MW0177175, MW0177176, GFW44268, HAL57735, HAL47233, HAL101320).

**Stellaria zolotukhinii* A.L.Ebel. A1 – A4, ZM1 (TK-003378, TK-003379, TK-003380, TK-003381, TK-003382, TK-003383, TK-003384, TK-003385).

Crassulaceae (3 spp.)

Rhodiola algida (Ledeb.) Fisch. & C.A.Mey. A3, A4, A6, KAD1, KAD6, KAD7, ZM1 (NS0026117, NS0026118, MW0090520, MW0090515, MW0090521, MW0090516, MW0180574, MW0180575, MW0180576, MW0180571, MW0180572, MW0180573, MW0180577, MW0090523, MW0090514, MW0090518, MW0090519, MW0090522, MW0090517, ALTB1100004655, ALTB1100004702, ALTB1100005039, ALTB1100005315, ALTB1100005398, ALTB1100005543, ALTB1100005549, ALTB1100005551, ALTB1100005559, ALTB1100005574, ALTB1100005582, ALTB1100005590, ALTB1100005595, ALTB1100005611, ALTB1100005614, ALTB1100005619, ALTB1100005664, ALTB1100005738, ALTB1100005753, ALTB1100005758, ALTB1100005786, ALTB1100005844, ALTB1100005852, OSBU10428, UBU1876, TK-003020).

Rhodiola krylovii Polozhij & Revjakina. A3, ZM1 (TK-001368, TK-003418, TK-003417, BRNU623350).

**Sedum populifolium* Pall. A2, A4 – A6, ZM1 (MW0592718, MW0089940, MW0089941, MW0160972, MW0089928, MW0089933, MW0089921, MW0089924, MW0089938, MW0089920, MW0089925, MW0089926, MW0089927, MW0089929, MW0089930, MW0089931, MW0089932, MW0089934, MW0089935, MW0089936, MW0089937, MW0089939, MW0089922, MW0089923).

Cyperaceae (1 sp.)

Carex martynenkoi Zolot. A2 (NSK0009452).

Dipsacaceae (1 sp.)

Scabiosa austroaltaica Bobrov. KAD1, KAD2, KAD6 (TK-003429).

Euphorbiaceae (7 spp.)

Euphorbia alpina C.A.Mey. ex Ledeb. A1, A3, KAD1, KAD6, ZM1 (NS0000560, MW0154147, MW0156615, MW0156616, MW0156617, MW0156618, MW0156619, MW0156621, MW0154136, MW0156620, MW0154140, MW0154132, MW0185174, MW0185173, MW0154137, MW0154134, MW0154139, MW0154135, MW0154141, MW0154142, MW0154144, MW0154146, MW0154148, MW0154143, MW0154138, MW0154145, TK-003036).

Euphorbia altaica C.A.Mey. ex Ledeb. A1, A3 (NS0000148, MW0154156, MW0154157, MW0154152, MW0154149, MW0154151, MW0154153, MW0154154, MW0154155, MW0154150, TK-003049, TK-004204, TK-004205, TK-004206, TK-004207, TK-004208, TK-004209, TK-004210, TK-004211, TK-004212).

Euphorbia blepharophylla C.A.Mey. ex Ledeb. KAD5 (KUZ-KAZ11514, KUZ-KAZ11516, KUZ-KAZ11517, KUZ-KAZ11519, KUZ-KAZ11520, KUZ-KAZ11522, KUZ-KAZ11523, KUZ-KAZ11525, KUZ-KAZ11526).

Euphorbia macrorhiza C.A.Mey. ex Ledeb. A3, KAD1, KAD2, KAD5, KAD6 (NS0000561, NS0009862, NS0009861, MW0154344, MW0154345, MW0154346, MW0154347, TK-003005).

Euphorbia rupestris C.A.Mey. ex Ledeb. A3 (NS0009870, NS0009869, NS0009868, NS0009867, NS0009866, NS0009865, NS0009864, NS0009863, NSK0028848, MW0154388, MW0154386, MW0154389, MW0154387, TK-003016).

**Euphorbia sajanensis* (Boiss.) Baikov. A5, A6 (TK-004213, TK-004214, TK-004215, TK-004216, TK-004217, TK-004218, TK-004219, TK-004220, TK-004221).

Euphorbia saurica Baikov. KAD4 (TK-002350).

Fabaceae (72 spp.)

Astragalus aksaicus Schischk. ZM1 (TK-000057).

Astragalus argutensis Bunge. A3, ZM1 (MW0183090, MW0102325, MW0102326, MW0102327, MW0102328, MW0102329, ALTB1100018489, ALTB1100018498, ALTB1100018506, ALTB1100018514, ALTB1100018577, ALTB1100018593, OSBU11796).

Astragalus baitagensis Sanchir ex N.Ulziykh. KAD9 (MW0183098, MW0183099).

Astragalus banzragczii N.Ulziykh. KAD9 (MW0593086).

Astragalus burtschumensis Saposhn. ex Sumnev. KAD5 (TK-000051, TK-000071, TK-000072). This taxon potentially occurs beyond KAD5.

Astragalus chamonobrychis Podlech. ZM1, ZM2 (LE01017805, LE01017806, LE01017867, LE01017868).

Astragalus gebleri Fisch. ex Bong. & C.A.Mey. KAD5 (MW0101945, KUZ-KAZ07610).

Astragalus glomeratus Ledeb. KAD3, KAD6 (MW0101944, KUZ-KAZ07601, KUZ-KAZ10469).

Astragalus fragiformis Willd. KAD6 (K001090667, K001090668 [as *A. inflatus* DC.]).

Astragalus granitovii Sanchir ex N.Ulziykh. KAD9 (MW0183200, MW0183201).

Astragalus gregorii B.Fedtsch. & Basil. KAD7, KAD9 (LE 01018341).

Astragalus katunicus Pjak. A3 (TK-000112, TK-000113, TK-000114, TK-000115, TK-000116, TK-000117, TK-000118, TK-000119, TK-000120, TK-000121, TK-000122, TK-000123, TK-000124, TK-000125, TK-000126, TK-000127, TK-000128, TK-000129, TK-000130, TK-000131, TK-000132, TK-000133, TK-000134, TK-000135, TK-000136, TK-000137, TK-000138, TK-000139, MW0161166).

Astragalus kendyrlyki M.Popov. KAD4 (LE00052819).

**Astragalus kurtschumensis* Bunge. KAD5 – KAD7 (MW0183259, MW0183260, GFW45634, GFW45635, KUZ-KAZ06489, KUZ-KAZ10456, KUZ-KAZ10473, KUZ-KAZ10475).

Astragalus leptocaulis Ledeb. KAD1, KAD5, KAD6 (MW0102317, MW0101850).

Astragalus luxurians Bunge. A3, KAD7, ZM1, ZM2 (MW0183296).

Astragalus majevskianus Krylov. KAD3, KAD4, KAD6 (TK-000150, TK-000151, TK-000152, MW0183310, MW0183311, MW0183313, MW0183314, MW0183312, MW0101830, MW0101831).

Astragalus ortholobus Bunge. A3, A4, KAD6 (K001090717, K001090718).

**Astragalus palibinii* Polozhij. A2 (TK-000179, TK-000180, TK-000181, TK-000182, TK-000183, TK-000184, TK-000185, TK-000186, NS0000504, MW0101641, MW0101639, MW0101640).

Astragalus petropylensis Bunge. KAD1, KAD3 – KAD6 (MW0101637, MW0101638, KUZ-KAZ06482, KUZ-KAZ06483).

Astragalus politovii Krylov. KAD7, ZM1, ZM2 (NS0000505, MW0101631, MW0101630, TK-000192, TK-000193, TK-000194, TK-000195, TK-000196).

Astragalus pseudoaustralis Fisch. & C.A.Mey. A3, KAD1, ZM1 (NS0000506, MW0101596, MW0101595).

Astragalus pseudotesticulatus Sanchir ex N.Ulziykh. KAD9 (NS0010205, MW0183441, MW0183440).

Astragalus pseudovulpinus Sanchir ex N.Ulziykh. KAD9 (MW0593200, MW0593201, MW0593202).

Astragalus pycnolobus Bunge. KAD2, KAD5, KAD6 (KUZ-KAZ07595).

Astragalus rudolffii N.Ulziykh. KAD9 (LE 01017812, LE 01017813, LE 01017814, LE 01017815, LE 01017836, LE 01031065).

Astragalus sanczirii N.Ulziykh. KAD9.

Astragalus scleropodius Ledeb. KAD3, KAD6 (TK-003009).

Astragalus steinbergianus Sumnev. KAD5 (TK-000215, TK-000216, TK-000217, TK-000218, TK-000219, TK-000220, TK-000221, TK-000222, TK-000223MW0847302, MW0847303).

Astragalus tephrolobus Bunge. ZM1 (NS0000508).

Astragalus tschuensis Bunge. KAD4, ZM1 (MW0101315, MW0101316, GFW45663).

Astragalus ulziykhutagii Sytin. KAD9.

**Astragalus vaginatus* Pall. A3, A4, KAD1, ZM1 (NS0000502, MW0101193, MW0101194, MW0101192, MW0101195, MW0101190, MW0101191).

Astragalus veresczaginii Krylov & Sumnev. KAD2, KAD6 (TK-000245, TK-000245, TK-000247, MW0101176, MW0101177, MW0101178, MW0101179, MW0101180).

Astragalus xanthotrichus Ledeb. KAD6 (MW0101159, KUZ-KAZ01600, KUZ-KAZ01601, KUZ-KAZ01602, KUZ-KAZ01603, KUZ-KAZ01604).

Astragalus zaissanensis Sumnev. KAD5, KAD6 (TK-000252).

**Hedysarum consanguineum* DC. A2 – A6, KAD6, ZM1 (NSK0009880, NSK0066399, NSK0066400, NSK0066401, NSK0066402, NSK0066403, NSK0005984, NSK0009295, NS0008011, MW0099299, MW0099309, MW0099291, MW0099307, MW0099317, MW0099310, MW0099305, MW0099294, MW0099295, MW0099298, MW0099302, MW0099303, MW0099304, MW0099306, MW0099308, MW0099311, MW0099314, MW0099315, MW0099283, MW0099284, MW0099300,

MW0099285, MW0099287, MW0099289, MW0099292, MW0099301, MW0099286, MW0099296, MW0099577, MW0099312, MW0099313, MW0099316, MW0099288, MW0099290, MW0099293, MW0099159, MW0099170, MW0099577, OSBU10323).

Hedysarum theinum Krasnob. A3, KAD1, KAD6 (NS0000257, NS0000258, NS0000256, NS0000255, NS0000254, NS0000253, NS0000252, NS0000251, NS0000250, NS0000247, NS0000248, NS0000249, NSK0009301, NS0008041, MW0099058, MW0099060, MW0099059, MW0099055, MW0593367, MW0593366, MW0593368, MW0099053, MW0099057, MW0099054, MW0099056).

Hedysarum tschuense A.I.Pyak & A.L.Ebel. A3 (NS0000517, TK-000411, TK-000412, TK-000413, TK-003023).

Lathyrus krylovii Serg. A2, A4, A5, KAD1, KAD6 (TK-000419, TK-000426, TK-000427, TK-000428, TK-000429, TK-000430, TK-000431, TK-000432, TK-000433, NS0000518, MW0077540).

Oxytropis acanthacea Jurtzev. ZM1 (MW0101039).

Oxytropis aigulak Saposhn. ZM1 (TK-000258, TK-000259).

Oxytropis alpestris Schischk. ZM1 (TK-000262, NS0000519, NSK0011995, NS0010233, NS0010232, NS0010231, NS0010230, NS0010229, NS0010228, NS0010227, NS0010226, NS0011965, NS0011964, MW0100980).

**Oxytropis ammophila* Turcz. A2 (NS0000520, MW0161184, MW0161183, TK-000263).

**Oxytropis argentata* (Pall.) Pers. A1, A3, KAD1, KAD6, ZM1 (NS0000521, MW0100855, MW0100856, MW0100857, MW0100858, MW0100859, MW0100860, MW0100861, MW0100862, MW0847978).

**Oxytropis bracteata* Basil. A2 (NS0000522).

Oxytropis confusa Bunge. A3, KAD1, KAD2, KAD6 (NS0000524).

**Oxytropis eriocarpa* Bunge. A3, A4, A6, ZM1 (ALTB1100007456).

Oxytropis hystrix Schrenk. KAD2, KAD3 (KUZ-KAZ11484).

Oxytropis inaria (Pall.) DC. A1, KAD1 (NS0000525, ALTB1100007125).

**Oxytropis includens* Basil. A2 (NS0000526, NSK0012597, NSK0012596, NS0010237, NS0010236, NS0010235).

**Oxytropis intermedia* Bunge. A3, A4, ZM1 (NS0000527, ALTB1100007133).

Oxytropis kaspensis Krasnob. & Pshenich. A3 (NS0000528, NS0000313, NS0000314, NS0000315, NS0000309, NS0000310, NS0000311, NS0000312, NS0000306, NS0000307, NS0000308, NS0000305, ALTB1100000095).

Oxytropis komei Saposhn. ZM1 (TK-000306).

Oxytropis krylovii Schipcz. KAD6. (TK-000307, TK-000308, MW0183817, ALTB1100019747).

Oxytropis ladyginii Krylov. ZM1 (NS0000529, NS0026093, NS0026094, ALTB1100006888, ALTB1100006603).

Oxytropis longibracteata Kar. & Kir. A3, KAD3, KAD6, ZM1 (NS0000530, KUZ-KAZ11485).

Oxytropis macrosema Bunge. A2 – A4, ZM1 (NS0000531, NS0012000).

Oxytropis melaleuca Bunge. KAD6 (LE00052818).

Oxytropis nivea Bunge. A4, ZM1 (NSK0013992).

Oxytropis physocarpa Ledeb. ZM1 (NS0000532, NSK0014154, NSK0014153, NSK0014152, NSK0014151, NSK0014150, NS0010257, NS0010256, NS0010255, NS0010254, NS0010253, NS0010252, NS0010251, NS0010250, NS0010249, NS0010248, NS0010247, NS0010246, NS0010245, NS0010244, NS0010243, NS0010242, NS0010241, NS0010240, NS0010239, NS0010238, NS0011986, NS0011985, NS0011984, NS0011983).

Oxytropis polyphylla Ledeb. ZM1 (K000881171, K000881171, MW0100085).

**Oxytropis reverdattoi* Jurtzev. A2 (NS0000515).

**Oxytropis saposhnikovii* Krylov. ZM1 (TK-000330, TK-000331, TK-000332, TK-000333, TK-000334, TK-000335, TK-000336, NS0000514, ALTB1100007094).

Oxytropis setosa (Pall.) DC. A1, A3, ZM1 (NS0000516, NS0025991, ALTB1100006133, ALTB1100006137, ALTB1100006145, ALTB1100006959 ALTB1100007153, ALTB1100007161).

**Oxytropis stenofoliola* Polozhij. A2 (TK-000348, TK-000349, TK-000350, NS0007341).

Oxytropis stenophylla Bunge. A3, ZM1 (K000881186).

Oxytropis sulphurea (Fisch. ex DC.) Ledeb. KAD1, KAD2, KAD6, ZM1 (NS0000511, NS0025997, KUZ-KAZ11486, KUZ-KAZ11487, KUZ-KAZ11488, KUZ-KAZ11489).

Oxytropis sumneviczii Krylov. KAD6 (TK-000354, TK-000355, TK-000356, TK-000357, TK-000358).

Oxytropis tenuis Palib. KAD5, ZM1 (LE01024760).

Oxytropis teres DC. A1, A3, KAD1, KAD6 (NS0000512, ALTB1100006921, ALTB1100006929, KUZ-KAZ06484).

**Oxytropis tschujae* Bunge. A3 – A5, KAD1, ZM1 (NS0000513, NSK0014789, NSK0014788, NSK0014787, NS0010215, NS0010214, NS0010213, NS0010212, NS0011811, NS0011810, NS0011809, NS0011808, NS0011807, NS0011806, NS0011805, NS0011804, NS0011803, NS0011802, NS0011801, NS0012010, NS0012009, NS0012008, NS0012007,

NS0012006, NS0012003, NS0012002, NS0012001, NS0011998).

Gentianaceae (2 spp.)

Gentianella sibirica (Kusn.) Holub. A3, KAD1, KAD6, ZM1 (NS0000574, TK-003455, TK-003454, TK-003453, TK-003449, TK-003448, TK-003443, TK-003441, KUZ-KAZ07814).

Swertia banzragczii Sanchir. KAD7 – KAD9 (NS0001124, UBU285, UBU292, MW0187839, MW0187840, MW0187844, MW0187845, OSBU10400).

Geraniaceae (1 sp.)

**Geranium laetum* Ledeb. A1 – A5, KAD1, ZM1 (NSK0063975, NSK0063976, NSK0063978, NSK0063979, NSK0063981, NSK0063982, NSK0063983, NSK0063984, NSK0063985, NS0022185, NS0022187, NS0021946, NS0023268, NS0023267, NS0023266, NS0023270, NS0023271, NS0023272, NS0023273, NS0023274, NS0023275, NS0023276, NS0023277, NS0023278, NS0023280, NS0023281, NS0023282, NS0023283, NS0023284, NS0023285, NS0023286, NS0023287, NS0023288, NS0023289, NS0023290).

Iridaceae (2 spp.)

Iris ludwigii Maxim. KAD1, KAD2, KAD6 (NS0009798, NS0009799, NS0009797, NSK0028904, NSK0028905), NSK0028906, NSK0028907, NSK0028908, NSK0071396, TK-003462, TK-003459, TK-003457).

**Iris tigridia* Bunge. A1 – A4, A6, KAD6 (TK-003466, TK-003465, TK-003464).

Lamiaceae (9 spp.)

Dracocephalum bungeanum Schischk. & Serg. A3, KAD8, ZM1 (NS0000576, TK-003015, TK-003478, TK-003471).

Dracocephalum krylovii Lipsky. A2 (KUZ015795 to KUZ015803, TK-003019).

Lagopsis darwiniana A.I.Pjak. ZM3 (NS0000474, TK-001726, TK-001727, TK-001728, TK-001729, TK-001730).

**Lophanthus krylovii* Lipsky. A3, KAD1, KAD4, KAD6, KAD8 (NS0000577, NS0006802).

Nepeta densiflora Kar. & Kir. KAD6, KAD8, KAD9 (NSK0068403, TK-000992, TK-003042).

Scutellaria altaica Ledeb. ex Sweet. A3, KAD1, KAD6 (ALTB1100010051, TK-003041, TK-003491, TK-003490, TK-003489, TK-003488, TK-003487, TK-003486, TK-003485).

**Thymus elegans* Serg. A1, A3, A4, ZM1 (TK-001050, TK-001051, TK-001052, TK-001053, TK-001054, TK-003496, TK-003495, TK-003493, NS0000584).

Thymus narymensis Serg. KAD6, ZM1 (TK-001083, TK-001084, TK-003497).

Thymus schischkinii Serg. A3, A4, KAD6, ZM1 (NS0000586, TK-001098, TK-001099, TK-003001, TK-003501, TK-003500, TK-003498, KUZ-KAZ10188).

Liliaceae (6 spp.)

Gagea altaica Schischk. & Sumnev. KAD1, KAD2 (TK-000670, TK-000671, KUZ-KAZ11491, KUZ-KAZ11493, KUZ-KAZ11496, KUZ-KAZ11501, KUZ-KAZ11503, KUZ-KAZ11505).

Gagea ancestralis Levichev. A4, KAD1 (LE01010661).

Gagea azutavica Kotukhov. KAD6 (KUZ-KAZ11119, KUZ-KAZ11490).

Gagea goljakovii Levichev. A3, ZM1 (LE01010667, LE01010668).

Gagea kuraiensis Levichev. A3, ZM1 (LE01010674, LE01010675).

Gagea xiphoidea Levichev. A3, ZM1 (LE01010695, LE01010696).

Linaceae (1 sp.)

Linum violascens Bunge. A3, ZM1 (NS0000585, TK-003504, TK-003505).

Orobanchaceae (5 spp.)

Euphrasia altaica Serg. A3, A4, A6, KAD6, KAD7, ZM1, ZM2 (TK-001373, TK-001375, TK-001376, TK-001377, TK-001378, TK-001379, TK-003560, NS0000592).

Euphrasia schischkinii Serg. A1, A3 – A6, KAD6 – KAD9, ZM1 (TK-001380, TK-001381, TK-001382, TK-002065, TK-001383, TK-001384, TK-001385, TK-002022, TK-003557, NS0000593).

Pedicularis altaica Stephan ex Steven. KAD3, KAD5, KAD9, ZM1. (ALTB1100014126 ALTB1100014140, ALTB1100014153, ALTB1100014162, ALTB1100017953, ALTB1100017956, TK-003576, KUZ-KAZ11509, KUZ-KAZ11510).

Pedicularis brachystachys Bunge. A1 – A5. (ALTB1100012948, ALTB1100015117, ALTB1100015429, ALTB1100015941, ALTB1100015957, ALTB1100015965, ALTB1100015973, ALTB1100017182, TK-003571, TK-003569, TK-003568, TK-003567, TK-003566, TK-003565, TK-003563).

Pedicularis moschata Maxim. A6, KAD7 – KAD9, UM, ZM1. (ALTB1100015658, ALTB1100013662, ALTB1100013694, ALTB1100010956).

Papaveraceae (4 spp.)

Corydalis grubovii Mikhailova. ZM1 (NS0000581, NSK0063707, NS0020635, NS0020634, NS0020633, NS0020641, NS0020640, NS0020639, NS0020638, ALTB1100010364, ALTB1100009795).

Corydalis nobilis (L.) Pers. A1 – A3, KAD1 – KAD4, KAD6 (NS0000573, NS0000510, NSK0063717, NSK0063718, NSK0063716, NS0020666, NS0020665, NS0020664, NS0020663, NS0020662, NS0020661, NS0020660, NS0020659, NS0020658, TK-003555, TK-003554, TK-003552, TK-003551, TK-003550, TK-003548, TK-003545, TK-003540, TK-003537).

Corydalis pauciflora (Stephan) Pers. A3 – A6, KAD1, KAD6, ZM1 (NS0007336, NS0000582, TK-003533, TK-003532, TK-003531, TK-003530, TK-003529, TK-003525, TK-003519, TK-003516, TK-003511, TK-003510, TK-003507).

Papaver kuvajevii Shaulo & Sonnikova. A5, A6 (NS0007336, NS0000582, NS0000319).

Plantaginaceae (3 spp.)

Linaria zaissanica Semiotr. KAD5, KAD9.

Veronica reverdattoi Krasnob. A2, A6 (TK-001386, NS0000570, NS0000422, NS0000420, NS0000421).

Veronica sessiliflora Bunge. A1, A3, A4, KAD1, ZM1, ZM2 (ALTB1100013492, ALTB1100013858, ALTB1100018255, ALTB1100018448, TK-003574, TK-003573, TK-003574).

Plumbaginaceae (1 sp.)

Limonium congestum (Ledeb.) Kuntze. ZM1 (NS0006758, NS0006759, ALTB1100010010, ALTB1100009317, ALTB1100009983, HAL58042, TK-003014).

Poaceae (36 spp.)

Bromopsis altaica Peschkova. A3, A4, ZM1 (NSK0000608, NSK0000607, ALTB1100021072, ALTB1100021782, ALTB1100021790).

Elymus besczetnovae Kotukhov. KAD1 (KUZ-TIP089, KUZ-TIP090).

Elymus buchtarmensis Kotukhov. KAD6 (KUZ-TIP104, KUZ-TIP105).

Elymus goloskokovii Kotukhov. KAD1 (ALTB).

Elymus karakabinicus Kotukhov. KAD6 (KUZ-KAZ11108).

Elymus lineicus Kotukhov. KAD1 (KUZ-TIP110, KUZ-TIP111).

Elymus longespicatus Kotukhov. KAD1 (KUZ-TIP083, KUZ-TIP084, KUZ-TIP085, KUZ-KAZ11115, KUZ-KAZ11116, KUZ-KAZ11121).

Elymus marmoreus Kotukhov. KAD6 (KUZ-TIP095, KUZ-TIP096).

Elymus occidentali-altaicus Kotukhov. KAD1 (KUZ-TIP113).

Elymus sarymsactensis Kotukhov. KAD6 (LE00052822, LE01065557).

Elymus sauricus Kotukhov. KAD4 (KUZ-TIP115, KUZ-TIP116).

Elymus sibinicus Kotukhov. KAD2 (KUZ-TIP094).

Elymus tarbagataicus Kotukhov. KAD6.

Elymus tzvelevii Kotukhov. KAD6 (KUZ-TIP114).

Elymus ubinica Kotukhov. KAD1 (KUZ-TIP081, KUZ-TIP082, KUZ-TIP093, KUZ-TIP108, KUZ-TIP109).

Elytrigia czindogatuica Kotukhov. A3 (KUZ-TIP100, KUZ-TIP101).

Limnas veresczaginii Krylov & Schischk. KAD6 (MW0591241, MW0011996, MW0011997, MW0011998, MW0011999, MW0012000, MW0012001, MW0012002, MW0012003, KUZ-KAZ10273).

Poa actruensis Olonova. A3 (TK-003295).

Poa altaica Trinius. A4, KAD1, ZM2 (NSK0000468, NS0008402, NS0025602, TK-003624).

Poa kuraica Olonova. A3 (TK-001305, TK-001996, TK-001997).

Poa mariae Reverdatto. A2 – A4, ZM1 (NS0000335, TK-001308, TK-001309, TK-001310, TK-003302).

Poa polozhiae Revjakina. A3 (TK-003301).

Poa pseudoaltaica (Olonova) Olonova. A3 – A5 (TK-003303).

Poa sobolevskiana Gudoschnikov. ZM1 (TK-001307).

Poa veresczaginii Tzvelev. A3, KAD6, KAD7, ZM1 (TK-003039, TK-003294).

Puccinellia kalininae Bubnova. KAD5, ZM1. (LE01011296).

Puccinellia kreczetoviczii Bubnova. A5, A6, ZM1 (NSK0020124).

Stipa argillosa Kotukhov. KAD5 (KUZ-TIP001, KUZ-TIP002, KUZ-TIP003, KUZ-TIP004, KRA 436051, KRA 436052).

Stipa austroaltaica Kotukhov. KAD6 (LE00052820, LE00052821, KRA).

Stipa austromongolica M.Nobis. ZM1 – ZM3 (KRA, LE)

Stipa × kamelinii Kotukhov. KAD4 (KUZ-TIP025, LE, KRA 436045, KRA 436046, KUZ – 7 sheets).

Stipa karakabinica Kotukhov. KAD6 (KUZ-TIP051, KUZ-TIP052, KUZ-TIP053, KUZ-TIP054, KRA 451780, KRA436020, KRA 436022, KRA 436024, KRA 436027).

Stipa kempirica Kotukhov. KAD3 (KUZ-TIP050, LE, KRA 436044).

Stipa kotuchovii M.Nobis. KAD4 (KUZ-TIP013, LE, KRA 436032, KRA 435918, KRA 436039, KRA 436040).

Stipa sczerbakovii Kotukhov (including *S. pavlovii* Kotukhov). KAD3 – KAD6 (KUZ-TIP027–KUZ-TIP038, LE, KRA 436031).

Stipa zaissanica Kotukhov. KAD6, KAD7 (KUZ-TIP012, LE, KRA 436028, KRA 436029).

Ranunculaceae (31 spp.)

Aconitum biflorum Fisch. ex DC. A5, A6 (NS0000565, NS0007323, NS0011466, NS0011465, NS0011464).

Aconitum decipiens Voroschilov & Anfalov. A3, A4, KAD1, ZM1 (NS0000564, NS0000603, NS0007335, NS0007322, NS0007321, NS0007320, NS0007319, NS0007318, NS0007317, NS0007316, NS0007315, NS0007314, NS0007313, NSK0023443, NSK0023442, NS0007312, NS0007311, NS0007310, NS0007309, NS0007308, NS0007307, NS0007306, NS0007305, NS0007304, NS0007303, NS0007302, NS0007301, NS0007300, NS0007299, NS0007298, NS0007297, NSK0023440, NSK0023441, NS0007437, NS0007438, NS0007439, NS0007440, NS0007441, NS0007292, NS0007293, NS0007294, NS0007296, NS0007295, NSK0023444, NSK0023445, NSK0023446, NSK0023447, NSK0023448, NSK0023449, NSK0023450, NSK0023451, NSK0023461, NSK0023460, NSK0023459, NSK0023458, NSK0023457, NSK0023456, NSK0023455, NSK0023454, NSK0023453, NSK0023452, NS0011481, NS0011480, NS0011479, NS0011478, NS0011477, NS0011476, NS0011475, NS0011474, NS0011473, NS0011472, NS0011471, NS0011470, NS0011469, NS0011468, NS0011467, NS0010581).

Aconitum gubanovii Luferov & Vorosh. KAD9 (MW0592354, MW0592359).

Aconitum krylovii Steinberg. A1 – A4 (TK-001390, NS0007325, NS0000500, TK-003029).

Anemone umbrosa C.A.Mey. A3, KAD1, KAD6 (TK-004195, TK-004196, TK-004197, TK-004198, TK-004200, TK-004201, TK-004202, TK-004203). This species may be subendemic, or even more widespread.

Aquilegia daingolica Erst & Schaulo. KAD7 (TK-001467, TK-001468, MW0178076).

Aquilegia xinjiangensis Erst. KAD7 (XJA-0003378).

Delphinium aemulans Nevski. A1, KAD3, KAD5 – KAD7 (TK-003011).

Delphinium austroaltaicum A.L.Ebel. KAD3, KAD6 (TK-001391, TK-001392, TK-001393, TK-001394, TK-001395, TK-003045).

Delphinium barlykense Lomon. & Khanm. A3, KAD4, KAD6, ZM1, ZM3 (NS0000155, NS0000154, NS0000153).

Delphinium eglandulosum Chang Y.Yang & B.Wang. KAD8, KAD9 (TK-004241, TK-004242).

Delphinium gubanovii N.Friesen. KAD9, ZM2 (MW0592326, MW0592327)

Delphinium inconspicuum Serg. A3 – A6, KAD6 – KAD9, ZM1 – ZM3 (TK-001396, NS0008674, NS0008675, NS0008676).

Delphinium mirabile Serg. A3, ZM1 (TK-001405, TK-001406, MW0076239, MW0178216, MW0178217, MW0178218, MW0178219).

Delphinium pseudocyananthum Chang Y.Yang & B.Wang. KAD7.

Delphinium reverdattoanum Polozhij & Revjakina. A3, ZM1 (TK-001407, TK-001408, TK-001409, TK-001410, TK-001411).

Delphinium sauricum Schischk. KAD4 (MW0829936, TK-001412, TK-001413, TK-003043).

Delphinium shawurense W.T.Wang. KAD4 (TK-004243).

Delphinium sinoelatum Chang Y.Yang & B.Wang. KAD4.

Delphinium tarbagataicum Chang Y.Yang & B.Wang. KAD3.

Delphinium ukokense Serg. A3, KAD6, ZM1 (TK-001414, TK-001415, LE01078645, LE01078645, LE01078667, LE01078669, LE01078670, LE01078681, NS0000566).

Ranunculus akkemensis Polozhij & Revjakina. A3, ZM1 (TK-001416, TK-003038).

Ranunculus lasiocarpus C.A.Mey. A2, A3, A5, A6, ZM1 (MW0072008, MW0178880, MW0178882).

Ranunculus revushkinii A.I.Pjak & Schegoleva. ZM1 (NS0000355, TK-001417, TK-001418).

Ranunculus sapozhnikovii Schegoleva. ZM3 (NS0000356, TK-001419).

Ranunculus schischkinii Revushkin. A1, A3 (TK-001420, TK-001421, TK-001422, TK-001423, TK-001424, TK-001429, NS0000356).

Ranunculus schmakovii Erst. ZM1 (NS0033950, ALTB1100000011).

Ranunculus tuvinicus Erst. ZM1 (ALTB1100000001).

Thalictrum bykovii Kotukhov. KAD6 (KUZ-TIP072–KUZ-TIP077, KUZ-KAZ10416, KUZ-KAZ1123, KUZ-KAZ11125, ALTB1100000040).

**Thalictrum schischkinii* N.Friesen. A6, ZM1 (MW0070863, MW0070864, MW0070865, MW0070866, MW0070867).

Thalictrum zaissanicum Kotukhov. KAD5, KAD6 (KUZ-TIP078, KUZ-TIP079, KUZ-TIP080, TK-003044).

Rosaceae (27 spp.)

Alchemilla altaica Juz. A1, KAD1 (TK-003720, TK-003721).

Alchemilla biquadrata Juz. A1 (LE01035440, LE01035441, LE01035442).

Alchemilla curaica Juz. A4, KAD1, KAD6, ZM1 (LE01035457, LE01035458).

Alchemilla curvidens Juz. A1 (MW0091441, MW0091442).

Alchemilla dasyclada Juz. A1, A3, A4, A6 (LE01035467).

Alchemilla denticulata Juz. A1, A3 (NS0016481).

Alchemilla diglossa Juz. A3, A5 (MW0949378).

**Alchemilla ledebourii* Juz. A4, KAD1, KAD3, KAD6 (LE01081342, LE01081341).

Alchemilla pilosiplica Juz. A1 (TK-003719).

Alchemilla sanguinolenta Juz. A1, A2, A4 (LE01035535, LE01035536, LE01035537, LE01035538).

**Alchemilla schischkinii* Juz. A1, A3 (MW0091321).

**Potentilla elegantissima* Polozhij. A3, A6, KAD1 (TK-000549, NS0000590).

Potentilla inopinata Soják. ZM1 (LE 01009663).

**Potentilla jenissejensis* Polozhij & W.A.Smirnova. A4 – A6, ZM1 (TK-000582, TK-000583, TK-000584, MW0094497, MW0181883, MW0181884, MW0181885, MW0181886).

Potentilla khanminczunii Kechaykin & Shmakov. A3, ZM1 (ALTB 1100035874, ALTB 1100035499).

**Potentilla kryloviana* Th.Wolf. A3, A4, ZM1 (LE00052018, LE01071483, LE01071495, LE01071576, LE01071632, MW0181887, MW0181888, MW0094477, NS0000589).

Potentilla laevipes Soják. KAD9, ZM2 (MW0181889, TK-003050).

Potentilla laevissima Kamelin. KAD9 (MW0592765, MW0592766).

Potentilla rigidula Th.Wolf. ZM1 (NS0026463, NS0026464, NS0026465, MW0181995).

Potentilla rudolfii Kechaykin & Shmakov. ZM1 (LE01035805, ALTB 1100032123, ALTB 1100035446).

Potentilla salsa Kotukhov. KAD5 (KUZ-TIP091, KUZ-TIP092, ALTB1100000096).

Potentilla schmakovii Kechaykin. KAD9, ZM1 – ZM3 (MW0592784, ALTB 1100035745, ALTB 1100035437).

Potentilla smirnovii Kechaykin. A3 (ALTB 1100035891, ALTB 1100035883).

Potentilla tuvinica Artemov. A6 (NS0000348, NS0000349).

**Rosa oxyacantha* M.Bieb. A3, A4, A6, KAD1 (NS0000588, NS0004968).

Sanguisorba azovtsevii Krasnob. & Pshenich. A1, A3 (NS0000368, NS0000369, NS0000367).

Sibiraea laevigata (L.) Maxim. A1, A3, KAD1, KAD6 (TK-003018, KUZ-KAZ11511, KUZ-KAZ11512, KUZ-KAZ11513).

Rubiaceae (3 spp.)

Asperula kryloviana Serg. KAD6 (TK-001387).

Galium coriaceum Bunge. A3, A4, ZM1 (MW0138058, MW0138059, MW0138064, MW0138065,MW0138066)

**Galium pobedimovae* E.A.Balde. A6 (NS0000591, NS0000213, NS0000214).

Santalaceae (1 sp.)

Thesium rupestre Ledeb. KAD1, KAD2, KAD6 (TK-003609, TK-003610, TK-003611).

Saxifragaceae (2 spp.)

Chrysosplenium filipes Kom. A2, A5 (TK-003652).

**Chrysosplenium ovalifolium* M.Bieb. ex Bunge. A1, A2, A5 (NS0000567, TK-003617).

Scrophulariaceae (2 spp.)

**Scrophularia altaica* Murray. A1 – A5, KAD1, KAD6 (NS0000568, TK-003606, TK-003605, TK-003600, TK-003599, TK-003598, TK-003596, TK-003592, TK-003590, TK-003589).

**Scrophularia multicaulis* Turcz. A2 (NS0000569, TK-003046).

Thymelaeaceae (2 spp.)

Daphne altaica Pall. KAD1 – KAD4, KAD6, KAD7 (NS0000571, NS0009147, NS0009146, TK-003012, TK-003654, TK-003660, TK-003661, TK-003668, KUZ-KAZ06583).

Stelleropsis altaica (Thiéb.-Bern.) Pobed. A1, A3, KAD1, KAD6 (NS0000572, NSK0024094, NSK0024095, NSK0024097, NSK0024098, NSK0024096, NS0011783, NS0011782, NS0011781, NS0011780, NS0011779, NS0011778, NS0011777, NS0011776, NS0011775, NS0011774, NS0011773, NS0011772, NS0011771, NS0011770, NS0011769, NS0011768, NS0011767, NS0011766, NS0011765, NS0011764, NS0011763, NS0011762, NS0011761, NS0011760, NSK0028988, NSK0028989, NSK0028990, NSK0028991, NSK0028992, TK-003687, TK-003688).

Violaceae (2 spp.)

Viola atroviolacea W.Becker. A3, KAD1 (K000370146, KUZ-KAZ06664).

Viola fischeri W.Becker. KAD1 (TK-003034).

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