Arctic high-mountain, steppe and nemoral species in the Angara-Chun interfluve flora

F S Yuzefovich and N N Tupitsyna
Krasnoyarsk State Pedagogical University named after V. P. Astaf’ev, 89 Ada Lebedeva St., Krasnoyarsk, 660049, Russia

E-mail: garmaline@ro.ru

Abstract. The article describes the species that are common in the Angara-Chun interfluve (Central Siberian Plateau) - pleiocene steppe and nemoral, pleistocene glacial and steppe, most of which are characterized by: a disjunctive range with no anthropogenic causes; the rarity of the species; small number of individuals, spatial limitation; shrinking habitat; disharmony with modern conditions. Nemoral relict species on the territory of the Angara-Chun interfluve are within the range, or on its northern or northwestern border. For species, region-zone confinement, chorological group, occurrence, abundance according to O. Drud are indicated.

1. Introduction
Relict species are the remains of an ancient flora, once widespread. They are characterized by: a disjunctive range with non-anthropogenic causes; the rarity of the species; a small number of individuals; spatial limitation; shrinking habitat; sometimes disharmony with modern conditions [1].

2. Materials and methods
Herbarium collected in the Angara-Chun interfluve by F. S. Yuzefovich in the field seasons 2014–2018. Analysis of literary sources by nomenclature, arealogy, ecological and geographical confinement.

Based on the reconstruction of the vegetation cover of Central Siberia from the Pliocene, performed according to M.P. Grichuk [2] and S.S. Voskresensky [3], V. V. Reverdatto [4] for the flora of Central Siberia (between the interfluve of Podkamennaya Tunguska and Chuni) gives polar-Arctic and alpine, steppe and nemoral species that show signs of relics. The work of A. V. Polozhiy [5]; A. V. Polozhiy and N. A. Olonova [6]; N. A. Olonova [7].

3. Results and discussion
After analysing the presented lists of relics, it was established that some of these species on the territory of the Angara-Chun interfluve are not relics, since they are within the range or on its border; the other part of the species, to which their own materials are added, can be attributed to relics. They are divided into groups according to age and region -zone confinement.

3.1. Pliocene steppe species
To Pliocene steppe relics, as A.V. Polozhiy notes [5], include xerophytes that supposedly migrated to southern Siberia from Ancient Middle-earth and Central Asia at the end of the Pliocene. G. A. Peshkova [8], however, suggests the existence on the territory of Eastern Siberia (or according to M. G. Popov [9]
of Central Siberia) from the Paleogene of subtropical deserts and tall grass steppes, which in the Neogene occupied hollow hilly spaces between deserts and forests of the Turgai type [10], which is confirmed by the modern distribution of species of the genus Ephedra here.

V.V. Reverdatto [4] also mentions the presence of tertiary plant pollen in Pliocene deposits. G. A. Peshkova [8] testifies that the Pliocene xerophytic steppes were reduced during the Quaternary, and at the time of the maximum glaciation of the Pleistocene they were separated but preserved. It follows that the steppe communities were a constant component of vegetation in the interfluve from the Pliocene. The following species are reckoned to this period:

**Ephedra monosperma** J.G. Gmel ex C.A. Mey. Mountain-steppe view from the South Siberian-Mongolian-East Asian area. It occurs sporadically on rocky slopes and in the steppes in the vicinity of the village Boguchany, the villages Manzya and Nevonka. Plenty of places.

**Gypsophila paniculata** L. Steppe Euro-Siberian-Central Asian species. It was recorded in a steppe meadow in the vicinity of the village Nevonka, on the island Goltyavino. Rarely.

M. G. Popov [11] considers the following as representative of the Pliocene landscapes:

**Silene wolgensis** (Hornem.) Otth, Forest-steppe Euro-Siberian-Central Asian species. It is indicated by L. B. Kolokolnikov and S. V. Gudoshnikov [12] 18 km below the village Irkineeva according to the collections of K. K. Poluyakhtova. It is rarely found on rocky southern slopes, steppe meadows in the vicinity of the village Boguchany and the villages Nevonka, Osinovy Mys. Single.

Pliocene age is confirmed by G. A. Peshkov [8] for:

**Oxytropis pilosa** (L.) DC. Forest-steppe European-West Siberian species, its range has declined from the time when it covered the entire steppe zone of Eurasia [13]. It grows along the banks of the Moktygin River, in steppe meadows in the vicinity of the villages Nevonka and Osinovy Mys. Occasionally.

Discussing the Eurasian species of Baikal Siberia, G.A. Peshkova [8] also suggests the Doplestocene age for:

**Linum perenne** L. Steppe Euro-Siberian species. Marked by A. I. Kytmanov [14] for the vicinity of the village Boguchany and the vicinity of the village Goltyavino. It is found in pine forests, on the southern slopes, along roadsides in the vicinity of the village Manzya. Occasionally.

The characteristics of Pliocene relics also include:

**Oxytropis lanata** (Pall.) DC. Steppe South Siberian-Mongolian species. Marked A. V. The position [15] is 18 km below the village of Irkineeva according to K.K. Poluyakhtova, for the village Yarki and the village Pinchugi according to the fees of G.A. Borovikova.

**Astragalus onobrychis** L. Steppe West-Palaearctic species. Collected once in a steppe meadow in the vicinity of the village Manzya. Single.

3.2. Nemoral species

Restoring the history of the forest vegetation development in Eastern (Middle) Siberia G.A. Peshkova and A.A. Kiseleva [16] claim that in the Pliocene the pre-reboreal flora prevailed here, which stood out from the arctotretic (Turgai flora A.N. Krishtovich) and consisting according to M.G. Popov [11] from oak and beech forests. Siberian non-moral species are genetically associated with broad-leaved forests, which according to spore-pollen analysis [2] along with Siberian conifers and deciduous species were present in forest formations of Central Siberia and in the interglacial phases. Currently, heat-loving woody representatives of the pre-reboreal flora are not found in the continental part of Siberia, but some shrubs and herbaceous plants of broad-leaved forests have been preserved. Siberian authors [4, 17, 18, 19, 20, 21] classify the following species as nemoral relics for different regions, however, on the territory of the Angara-Chun interfluve these species are within the range or on the northern or north-western border of distribution and are not relic.

**Stachys sylvatica** L. Northeast Asian species. Collected by N. V. Blagoveshchensky on the banks of the Angara River between the Pavlich and Aladyina rivers [22].
**Daphne mezereum** L. European-West Siberian species. Marked for the village of Kulakovo on the Angara River [23]. It is found in dark coniferous forests on the Moktygina River, in the vicinity of the village Nevonka. Single.

**Alnus hirsuta** Turcz. ex rupr. Northeast Asian species. It grows along the banks of rivers in the vicinity of the villages Manzya and Nevonka. Rarely.

**Smilacina trifolia** Desf. Northeast Asian species. It occurs in swampy meadows, in thickets of shrubs in the vicinity of the village Manzya. Single.

**Anemone reflexa** Stephan. North Asian species. Common in light coniferous and small-leaved forests, in forest meadows everywhere. Plenty of places.

### 3.3. Glacial species

Glacial, or Arctic high-mountainous, or glacial relics are species whose modern range is located in the alpine zone or (and) in the Arctic region. They entered the territory of the Central Siberian Plateau under the influence of a glacier and, finding ecologically close conditions, adapted to existence on a flat-hilly territory.

Glacial relics on the territory of the Angara-Chun interfluve are (without the "*" symbol - species indicated by V.V. Reverdatto [4]; with the symbol "*" by A.V. Polozhy [5]; with the symbol "**" by A.V. Polozhy, N.A. Olonov [6]; with the symbol "***" by N.A. Olonov [7]):

**Astragalus norvegicus** Grauer (Astragalus oroboides Hornem.). Arcto-Alpine Euro-Siberian species. Marked by A.V. Polozhy [15] for the Chuna River "... the location divorced from the general range ... in the modern flora, of course, is relict ..." [24].

**Potentilla nivea** L. Arcto-Alpine Holarctic species. Given for the collections of G.A. Borovikov for the environs of the village of Zaledeeva [25].

**Viola biflora** L. Hyparctomontan holarctic species. It grows along the banks of the Moktygin and Angara rivers, in coniferous forests, on rocks in the vicinity of the village Manzya. Occasionally.

**Geranium krylovii** Tzvelev. Montana arcto-Siberian species. Given by A.I. Kytmanov as Geranium albiflorum Ledeb.: "Mixed forest, forest meadows. Chadobets, Motyginskaya road." [14].

**Poa alpigena** Lindm. Arcto-Alpine Holarctic species. Collected by K.K. Poluyakhtov on the Chuna River near the village of Chunoyar [26].

* **Juncus arcticus** Willd. Arcto-alpine circumboreal species. Marked by S.V. Gudoshnikov [27] for the rift "Tyumenets" on the Chuna River according to Tolmachev.

From the point of view of relictness criteria, the species we have collected are also interesting:

**Solidago lapponica** With. Hypoarctic Arctic-West Siberian species. It was noted in the cereal-Chemeritsa-white-headed coastal meadow on the banks of the Moktygin River [28]. Single. This is the southernmost location of the species, divorced from the main part of the range.

**Elytrigia villosa** (Drobow) Tzvelev. Hyparctomontan Middle Siberian endemic species. Collected once on a coastal meadow of herbs in the vicinity of the village Manza. This is the most southwestern location of the species, isolated from the main range.

### 3.4. Periglacial steppe species

The onset of the xerothermal period contributed to the spread of steppes, which were widely distributed in periglacial spaces and became competitors of glacial species. The steppe species are shown below, showing relict distribution in the interfluve area. These species are located near the northern or northwestern border of the range.

**Astragalus suffruticosus** DC. Forest-steppe East European-Turan-North Asian species. It is found in pine and larch forests, on rocky slopes in the vicinity of the village Boguchany, the villages Kezhek, Manzya, Nevonka, Osinovy Mys, along the banks of the Moktygin River. Plenty of places.

**Chamaerhodos erecta** (L.) Bunge. Steppе East European-Turan-North Asian species. It lives in birch-pine, birch-aspen forests in the vicinity of the village Osinovy Mys. Occasionally.

**Delphinium grandiflorum** L. Steppe Northeast Asian species. It grows in the steppes, steppe meadows, rocky slopes in the vicinity of the village of Boguchany, the village Nevonka. Occasionally.
Eritrichium pectinatum (Pall.) DC. Mountain-steppe southern Siberian-Mongolian species. A.V. Polozhy [29] noted it at the mouth of the Biryusa river according to V.V. Reverdatto.

*** Puccinellia hauptiana (Krecz.) Kitag. Azonal-riverbed Holarctic species. Marked by G.A. Borovikov for the vicinity of the village Chadobets [26].

Stipa pennata L. Forest-steppe European-West Siberian species. It is found in the steppes and on rocky slopes in the vicinity of the village Manzya. Single.

** Veronica incana L. Mountain-steppe boreal-Iranian-Turan species. It occurs in the steppes, steppe meadows, rocky slopes everywhere in the territory of the interfluve. Plenty of places.

Leymus jenisseiensis (Turcz.) Tzvelev. (Elymus jenisseiensis Turcz.). Steppe Central Siberian endemic species. L. M. Cherepin [30] shows it in the vicinity of the village Boguchany and characterizes as a formed independent species of hybridogenic origin.

4. Conclusion
Pliocene steppe, nemoral, Pleistocene glacial and steppe species grow on the territory of the Angara-Chuna interfluve, most of which have relict signs. Of these, the leading places are occupied by species with Holarctic and North-East Asian ranges (4 species each). Species with Euro-Siberian, European-West Siberian, Euro-Siberian-Central Asian, East European-Turan-North Asian, South Siberian-Mongolian, Central Siberian endemic ranges (2 species each) lag behind them. With circum-boreal, West-Palearctic, Arcto-Siberian, Arcto-West Siberian, North Asian, Boreal-Iranian-Turanian, South Siberian-Mongolian-East Asian ranges of 1 species. Analysis of the area logical structure indicates the low specificity of the flora of the Angara-Chuna interfluve, which corresponds to the opinion of the relative uniformity of the flora of the temperate zone of Eurasia. However, ties with Europe, Central, and also with East Asia speak of the heterogeneous European-Asian formation of flora in the past. At the same time, European genetic ties clearly prevail.

Nemoral species on the territory of the Angara-Chuna interfluve are not relict, but they are within the range, or on its northern or north-western border.

Acknowledgments
The reported study was funded by Russian Foundation for basic Research, Government of Krasnoyarsk Territory, Krasnoyarsk Regional Fund of Science, to the research project 18-44-240006 «Natural and urbanized flora of the Yeniseysk Siberia».

References
[1] Elenevsky AG and Rodygina VI 2002 On the concept of “relic” and relictomania in plant geography Bulletin of Moscow Society of Naturalists 107(3) 39-49
[2] Grichuk M P 1955 On the history of vegetation in the Angara river basin Reports USSR Academy of Sciences 2 335-8
[3] Voskresensky S S 1957 Geomorphology of Siberia. Highlands and Lowlands of Eastern Siberia. Mountains of Southern Siberia (Moscow: MSU) p 316
[4] Reverdatto V V 1960 Glacial and steppe relics in the flora of Central Siberia in connection with the history of the flora Scientific readings in memory of MG Popov 1-2 111-31
[5] Polozhny A V 1964 Glacial relic species and associations in the lower reaches of the Podkamennaya Tunguska and Chuna rivers The vegetation cover of the Krasnoyarsk region (Novosibirsk: USSR Academy of Sciences. Sib. Branch) 1 60-4
[6] Polozhny A V and Olonov N A 1979 Novelties for the watershed flora of the Podkamennaya Tunguska and Chuna rivers Systematic notes on the materials of P.N. Krylov Herbarium of Tomsk State University 86 14-5
[7] Olonov NA 1998 Arctic high-mountain and steppe species in the flora of the interfluve of Podkamennaya Tunguska and Chuna Systematic notes on the materials of P.N. Krylov Herbarium of Tomsk State University 90 23–24
[8] Peshkova G A 1972 Steppe Flora of Baikal Siberia (Moscow: Nauka) p 207
[9] Popov MG 1953 On the relationship of forest (taiga) and the steppe in Central Siberia *Bulletin of Moscow Society of Naturalists* **58**(6) 81–85
[10] Krishtofovich A N 1958 Origin of the Angara land. *Materials on the history of the flora and vegetation of the USSR* **3** 7–41
[11] Popov M G 1949 *Essay on the Vegetation and Flora of the Carpathians* (Moscow: Publishing House of the Moscow Society of Naturalists) p 303
[12] Kolokol’nikov L B and Gudoshnikov S V 1976 Caryophyllaceae *Flora of the Krasnoyarsk region* **5** (3) 4–38
[13] Polozhiy A V 1965 Phlorogenetic analysis of the ostracis of Central Siberia. *Scientific notes of Tomsk University. Biology and soil science* **1** 18–25
[14] Kytmanov AI 1906 On the flora of vascular plants of the Angara River in part of it lying in the Yenisei District of the Yenisei Province *Izvestia of the Krasnoyarsk Branch of the East Siberian Branch of the Russian Geographical Society* **2**(1) 75–108
[15] Polozhiy A V 1960 Papilionaceae *Flora of the Krasnoyarsk Region* vol 6 (Tomsk: Publishing House of Tomsk University) p 94
[16] Peshkova G A and Kiselyova A A 1984 *Forest Complex of Species Features and Genesis of Siberian Flora* (Prebaikalia and Transbaikalia) (Novosibirsk: Nauka) pp 85–146
[17] Malyshev L M and Sobolevskaya K A 1981 *Rare and Endangered Plants of Siberia* (Novosibirsk: Nauka) p 224
[18] Malyshev L I and Peshkova G A 1984 *Features and Genesis of the Flora of Siberia (Transbaikalia and Transbaikalia)* (Novosibirsk: Nauka) p 265
[19] Kiseleva A A, Kazanovskiy S G, Verkhozina AV and Dudareva N V 1999 Nemoral relics in the taiga of the Northern Sayan region *Genesis of flora and vegetation of Baikal Siberia* (Irkutsk: Publishing House of Irkutsk University) 52–58
[20] Antipova E M and Zubareva E V 2017 *Sub-boreal Forest Flora of the Cansk Basin* (Krasnoyarsk: KrasSMU) p 293
[21] Antipova E M and Chebotareva O P 2019 Floral finds in the city of Abakan (Republic of Khakassia, Russian Federation) *IOP Conf. Ser.: Earth and Environmental Science* **315** (2019) 022021
[22] Bychennikova N K 1965 *Labiatae Juss. Flora of the Krasnoyarsk region* (Tomsk: Publishing House of Tomsk University) **9** 141–172
[23] Polozhiy A V 1977 *Thymelaeaceae Flora of the Krasnoyarsk region* (Tomsk: Publishing House of Tomsk University) **7** 31
[24] Polozhiy A V 1963 On the history of the formation of the Arctic flora of Central Siberia *Izvestiya SB AS USSR Series of Biological and Medical Sciences* **4**(1) 6–14
[25] Polozhiy A V and Loshkaryova L N 1975 *Rosaceae Family - Rosaceae Flora of the Krasnoyarsk region* **5**(4) 88–141
[26] Revardatto V V 1964 *Gramineae Flora of the Krasnoyarsk region* **2** 146
[27] Gudoshnikov S V 1965 *The Gingerbread Family - Juncaceae Vent. Flora of the Krasnoyarsk region* **3** 118–130
[28] Yuzefovich F S and Tupitsyna N N 2016 New findings of flowering plants in Angaro-Chunsky interfluve (Krasnoyarsk region) *Turczaninowia* **19**(3) 68–72
[29] Polozhiy A V 1977 *Boraginaceae Flora of the Krasnoyarsk region* **8** 126
[30] Cherpenin L M 1959 *Flora of the Southern Part of the Krasnoyarsk Territory Krasnoyarsk* vol 2 (Krasnoyarsk: Publishing House of KSPU) p 240