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A new concept of pine (*Pinus sylvestris* var. *hamata*) hemiboreal forests classification of the North-Western Caucasus

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Keywords: *Brachypodio–Betuletea*, Braun-Blanquet, Caucasus, classification, Europe, hemiboreal forests, phytodiversity.

Summary. Hemiboreal pine and pine-birch (*Pinus sylvestris*, *Betula pubescens* var. *litwinowii*) forests from the North-Western Caucasus were classified as two associations and four variants – *Bistorto carneae–Pinetum sylvestris* ass. nov. (var. *Rhododendron luteum*, var. *Avenella flexuosa*), *Aconito nasuti–Pinetum sylvestris* ass. nov. (var. *Centaurea phrygia* subsp. *abbreviata*, var. *Geranim robertianum*). They were included in the alliance *Asyneumo campanuloides–Pinion sylvestris* all. nov. and order *Alchemillo sericatae–Pinetalia sylvestris* Ermakov, Abdurakhmanova et Plugatar 2020 after cluster analysis performed. A new concept of the position of these Caucasian birch and pine-birch grass forests in the system of the European-Siberian class *Brachypodio pinnati–Betuletea pendulae* Ermakov et al. 1991 was proposed. All described associations belong to a special type of zonal small-leaved and light-coniferous hemiboreal forests of Northern Eurasia. It is confirmed by the distinct diagnostic species group of the class *Brachypodio pinnati–Betuletea pendulae* and their common ecological properties, floristic compositions and physiognomy. The North Caucasian hemiboreal forests together with analogous small-leaved and coniferous-small-leaved forests occurring in the upper part of the forest belt in the mountain ranges of Europe and Asia Minor may be considered as relic communities related by origin with the climate of the cold and dry periods of the Pleistocene.

Новая концепция классификации сосновых (*Pinus sylvestris* var. *hamata*) гемибореальных лесов Северо-Западного Кавказа

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Аннотация. В результате проведённой классификации сосновых и сосново-берёзовых (*Pinus sylvestris*, *Betula pubescens* var. *litwinowii*) гемибореальных лесов из северо-западного Кавказа описано две ассоциации и четыре варианта – *Bistorto carneae–Pinetum sylvestris* ass. nov. (var. *Rhododendron luteum*, var. *Avenella flexuosa*), *Aconito nasuti–Pinetum sylvestris* ass. nov. (var. *Centaurea phrygia* subsp. *abbreviata*, var. *Geranim robertianum*). Эти единицы включены в состав союза *Asyneumo campanuloides–Pinion sylvestris* all. nov. и порядка *Alchemillo sericatae–Pinetalia sylvestris* Ermakov, Abdurakhmanova et Plugatar 2020 по результатам кластерного анализа. Предложена новая концепция положения Кавказских сосновых и сосново-берёзовых травяных лесов в системе евросибирского класса *Brachypodio pinnati–Betuletea pendulae* Ermakov et al. 1991. Все описанные ассоциации принадлежат особому типу зональных мелколиственных и светлохвойных гемибореальных лесов Северной Евразии. Это подтверждается чёткой группой диагностических видов класса *Brachypodio pinnati–Betuletea pendulae* и их общими экологическими, флористическими и структурно-фитоценотическими признаками. Северокавказские гемибореальные леса вместе с аналогичными мелколиственными и хвойно-мелколиственными лесами, произрастающими в верхней части лесного пояса горных хребтов Европы и Передней Азии, могут рассматриваться как реликтовые сообщества, связанные своим происхождением с климатом сухих и холодных периодов Плейстоцена.

Introduction

The Western Caucasus is known as one of the centers of phytodiversity in Northern Eurasia formed as a result of a unique combination of various paleo-geographic and geological processes since Paleocene. The location of this mountain system between the 42–45 geographical latitudes has led to the predominance of thermophilous broad-leaved forests occupying a wide range of altitudes from 2–4 m to 2200 m. The first researchers already noted the ecological and plant-geographical originality of the mountain forest vegetation here and, first of all, the nemoral forests with the participation of endemic species of evergreens considered as relic Tertiary subtropical floristic elements (Kuznetsov, 1909). Subsequently, Maleev (1941) proposed the concept of two peculiar ecological and historical types of the modern Western Caucasian forests originating from different bioclimatic categories of ancient Paleocene vegetation: moist Arcto-Tertiary Colchis forest and hemi-xerophilous Mediterranean one. However, some peculiar communities in the Western Caucasus are still poorly studied. Pine (*Pinus sylvestris* var. *hamata* Steven) forests occurring in the upper part of the forest and subalpine belts represent one of these objects. Their massifs are found in the moderately cold and drier ecotopes in the areas close to the Main Caucasian Ridge, where they replace beech, beech-hornbeam and dark-coniferous forests prevailing in the Western Caucasus.

The study of the forest types in the Western Caucasus is mainly associated with the most widespread thermophilous broad-leaved communities (Grudzinskaya, 1953; Orlov, 1953; Gulisashvili et al., 1975; Bebiya, 2022). Some brief descriptions of pine forests from the North-Western Caucasus were published by Sosnin (1939), Ostapenko (1967), Gulisashvili et al. (1975), Mahatadze, Urushadze (1972), Gigauri et al. (1987).

In recent years, the forests diversity of the Western Caucasus was studied using the Braun-Blanquet approach (Grebenshchikov et al., 1990; Frantsuzov, 2006; Sokolova, 2012; Ermakov et al., 2022; 2023). As for the pine (*Pinus sylvestris* var. *hamata*) forests, then the results of their classification were published only for the Eastern Caucasus (Ermakov et al., 2019, 2020). The syntaxonomic system of plant communities dominated by another pine taxon – *Pinus brutia* var. *ptyusa* (Gordon & Glend.) Silba ex Farjon from the Western Transcaucasia was developed by Litvinskaya, Postarnak (2002) and Ermakov et al. (2024). All these plant communities were differentiated into two higher categories – the sub-Mediterranean *Erico–Pinetea* forests and the Mediterranean *Junipero–Pinetea sylvestris* forests. The new data obtained after our studies of *Pinus sylvestris* var. *hamata* forests in the North-Western Caucasus in 2016–2023 demonstrated their unique ecological and floristic features which are important for further development of pine forests classification for the North Caucasus as a whole.

The purpose of this study is to classify the pine (*Pinus sylvestris* var. *hamata*) forests of the North-Western Caucasus and analyze their position in the system of higher syntaxonomic units of Northern Eurasia.

Study area

The study area is located within two large mountain systems: the Lagonakskoye upland and the Skirda-Yatirgvarta massif (the western part of the Greater Caucasus) (Fig. 1). The relief of the Lagonakskoye upland consists of a number of local mountain ridges (Nagoy-Chuk, Azish-Tau, Lagonaksky, etc.) and lower plateaus. The altitudes of the area range from 1500 to 2300 m a. s. l. On the southern side, the Lagonakskoye highland is bordered by three large massifs – Fisht (2867 m), Oshten (2804 m) and Pshekha-su (2744 m). The Skirda-Yatyrgvarta mountain massif with the Trew peak (2395 m) resembles the Lagonakskoye upland but is smaller in area. A significant part of the study area is composed mainly of Jurassic and Cretaceous sedimentary limestone rocks, as well as sandstones, clay shale and conglomerates (Lozovoy, 1984).

The first frontal mountain ridges of the Western Caucasus are barriers to humid air masses coming from the west of the Black Sea. Therefore, the eastern part of the Lagonakskoye upland and Skirda-Yatyrgvarta mountain ridge, especially in areas of pine forests occurrence, are located in the so-called "Rain shadow". Climatic conditions change from the east (Skirda-Yatyrgvarta Ridge) to the west (the Fisht Mountain) from a drier continental to a humid temperate. According to the data of the Dzhuga meteorological station (eastern part of the study area, 2041 m a. s. l.), the mean annual temperature in the subalpine and adjacent forest belts is +3.7 °C, the warmest month (July) is +23 °C, the coldest (January) is –19 °C. The duration of the frost-free period is 134 days. The mean annual precipitation is 1320 mm. Stable snow cover (height of 53–106 cm) persists for 153 days (Rodimtsev, Zhivotov, 2018). In the western part of the study area, according to the Fisht meteorological station (the western slope of Fisht, 1770 m a. s. l.), the mean temperature of the coldest month (January) in the Lagonakskoye upland reaches –6.4 °C, the warmest (July) +15.5 °C, the mean annual temperature +4.6 °C, the mean annual precipitation is 1955 mm (Morozov, 2020). The height of the snow cover in the forest belt is about 400 cm. The mean duration of snow cover is 215 days (Pogorelov et al., 2019). Pine forests are found throughout the region, but their maximum concentration is observed in the Malaya Laba River basin. They occupy mainly the southern slopes on gravelly, rocky and rocky outcrops near the upper limit of the forests at altitudes of 1200–2400 m (Golgofskaya, 2003). Some communities are secondary after fires (Sosnin, 1939).

Data and methods

The field research was carried out in 2016–2023. We sampled 43 relevés of 100 m^2 in two mountain systems of the Western Caucasus: the Lagonakskoye upland (the westernmost part of the Greater Caucasian Ridge) and in the Skyrda-Yatyrguarta mountain ridge at altitudes of 1650–2180 m (Fig. 1). Within each relevé, the percentage cover of the tree, shrub, herb and moss layers was estimated and the cover of particular species in each layer was assessed. Percentage data of each species were converted in the seven-degree Braun-Blanquet (old) cover-abundance scale and constancy species was represented with five-degree scale (I – 1–20 %, II – 21–40 %, III – 41–60 %, IV – 61–80 %, V – 81–100 %) in final classification table. Geographical coordinates (WGS 84) and the altitude of relevés were recorded using a portable GPS device GPS map 60CSx. All relevés were input in database using the software TURBOVEG (Hennekens, Schaminée, 2001). The quantitative classification of the entire set of relevés was carried out using cluster analysis (Ward's method, Euclidian distance) implemented in Statistica 6.0. The quantitative floristic comparison of the lower-rank syntaxa (associations, subassociations, variants) was carried out using cluster analysis (Median method, Jaccard distance) implemented in PS-ORD – 4. The finalization of the classification table was done in the software Juice 7.0 (Tichy, 2002). The forest classification was carried out based on the Braun-Blanquet method (Westhoff, van der Maarel, 1973). The classification of pine (*P. sylvestris* var. *hamata*) forests is presented in a species-by-site table, in which diagnostic species were determined for each vegetation unit. Species with an indicator value higher than 40 were considered diagnostic. Results of comparative syntaxonomic analysis are represented in the synoptic table with five-degree scale for constancy of species. The syntaxa names were given in accordance with the International Code of Phytosociological Nomenclature (Theurillat et al., 2021). Taxonomy: Plants of the World Online (http://www.powo.science.kew.org) (for higher vascular plants) and Ignatov et al. (2006) (for bryophytes).

Results and discussion

The cluster analysis of the entire set of 43 relevés of pine grass forests showed their division at the highest hierarchical level of clustering into two groups A and B, each of which was also divided into two sub-clusters (A1, A2, B1, B2) (diagram in Fig. 2). A comparative floristic analysis of two

categories (A1 and A2) of pine forests identified by clustering results showed important ecological and floristic differences allowing their interpretation as associations in the Braun-Blanquet system. Accordingly, four categories (A1, A2, B1, B2) of pine forests identified at a lower hierarchical level on the dendrogram (Fig. 2) were assigned to variants of the associations. Based on the results of cluster analysis, a table of units of pine grass forests with demonstration of their characteristics was built (Table 1).

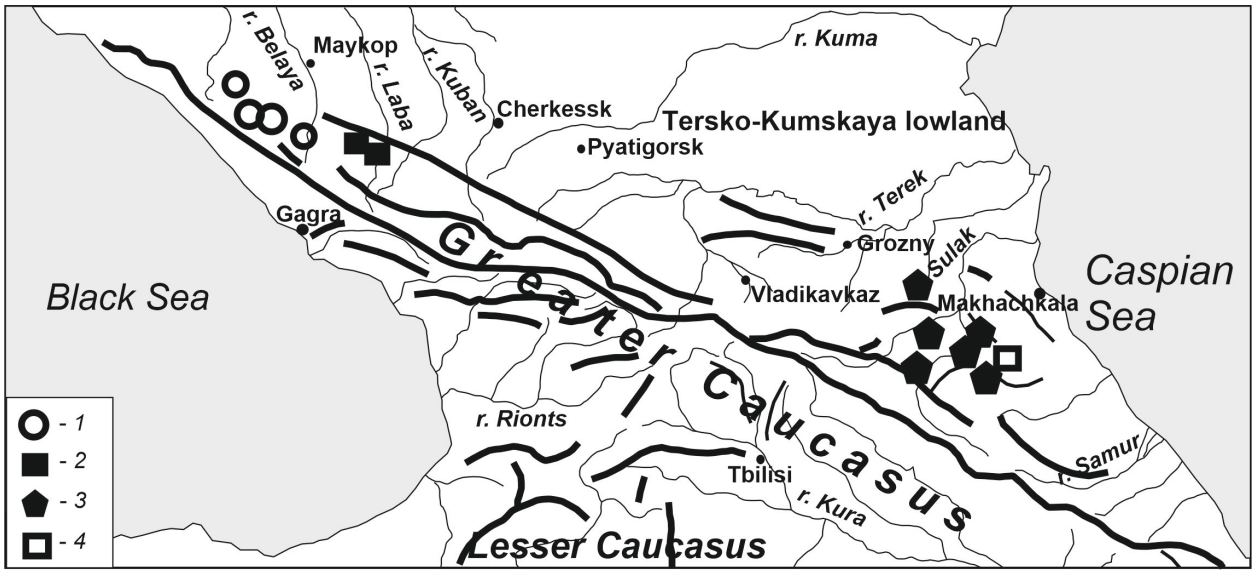

Fig. 1. Geographical locations of described associations and syntaxa used for the syntaxonomic analysis: 1 – association *Aconito nasuti–Pinetum sylvestris*; 2 – association *Bistorto carneae–Pinetum sylvestris*; 3 – alliance *Bupleuro polyphylli–Pinion sylvestris* (associations *Carici albae–Pinetum sylvestris*, *Ranunculo caucasicae–Pinetum sylvestris*, *Viburno lanatae–Pinetum sylvestris*, *Calamagrostio caucasicae–Pinetum sylvestris*); 4 – alliance *Onobrychido cornutae–Pinion sylvestris* (association *Onobrychido cornutae–Pinetum sylvestris*).

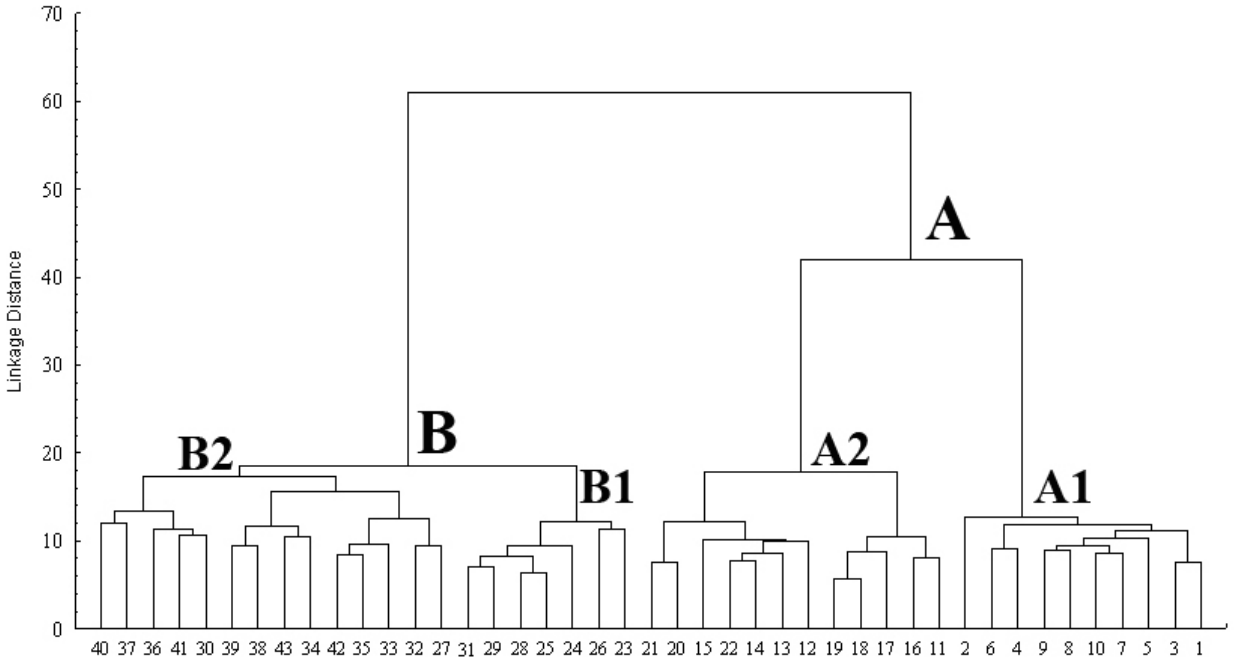

Fig. 2. Results of cluster analysis (Word's method, Euclidian distance) of 43 relevés of pine and pine birch (*Pinus sylvestris* var. *hamata, Betula pubescens var. litwinowii*) forests from the North-Western Caucasus. Associations: A – *Bistorto carneae–Pinetum sylvestris* (A1 – var. *Rhododendron luteum*; A2 – var. *Avenella flexuosa*); B – *Aconito nasuti–Pinetum sylvestris* (B1 – var. *Centaurea phrygia* subsp. *abbreviata*; B2 – var. *Geranim robertianum*).

Association ***Bistorto carneae–Pinetum sylvestris* ass. nov.** (relevés 1–22 in Table 1, syntaxa 5, 6 in Table 2).

Holotypus – relevé 3 (field nr. 49NE18) in Table 1.

Diagnostic species: *Aconitum cymbulatum, Anthoxanthum odoratum, Anthriscus schmalhausenii, Bistorta carnea, Cruciata laevipes, Campanula lactiflora, Luzula multiflora, Pimpinella rhodantha, Poa longifolia, Ptarmica biserrata, Pyrola rotundifolia, Vaccinium myrtillus*.

These are mesophilous pine grass forests occurring at the upper part of the forest belt of the Skirda-Yatyrgvarta mountain ridge (the Laba River basin) at altitudes of 1830–1950 m. Small areas of these communities are found on well-insulated southern steep slopes with rocky soils.

The tree layer dominated by pine (*Pinus sylvestris* var. *hamata*) has a cover of 40–60 % and a height of 23–26 m. Birch (*Betula pubescens* var. *litwinowii*) occurs in the second sub-layer. Dark coniferous species (*Abies nordmanniana, Picea orientalis*) are typical for the undergrowth, however these trees are ecologically depressed.

The main floristic peculiarity of the association is determined by the high constancy of light-demanding cold-tolerant mesophilous subalpine-forest plants included in the diagnostic combination. High constancy of boreal species – *Vaccinium myrtillus, Pyrola rotundifolia, Orthilia secunda* is observed here as well. The moss layer is poorly developed (3–5 % coverage).

The association is represented by two variants (var.). The var. *Rhododendron luteum* (syntaxon nr. 5 in Table. 2) includes communities with a well-developed shrub layer and a significant participation of moderately mesophilous herbs (*Brachypodium pinnatum, Psephellus dealbatus, Dianthus caucaseus, Fragaria vesca, Tragopogon reticulatus, Trifolium canescens, Vicia cracca*). The var. *Avenella flexuosa* (syntaxon nr. 6 in Table. 2) is characterized by a high constancy of subalpine-forest mesophytes – *Aquilegia olympica, Astrantia maxima, Campanula collina, Vicia balansae*.

Association ***Aconito nasuti–Pinetum sylvestris* ass. nov.** (relevés 23–43 in Table 1, syntaxa 7, 8 in Table 2).

Holotypus – relevé 25 (field nr. 758/444) in Table 1.

Diagnostic species: *Aconitum nasutum, Aconitum orientale, Daphne mezereum, Dryopteris filix-mas, Euphorbia macroceras, Juniperus communis, Lonicera caucasica* subsp. *orientalis, Swertia iberica*.

These are mesophilous birch-pine and birch (*Betula pubescens* var. *litwinowii*, *Pinus sylvestris* var. *hamata*) grass forests found near the upper boundary of the forest belt in the extreme north-western part of the Main Caucasian Ridge (the Lagonakskoye upland, Fisht-Oshtenskiy mountain ridge) at altitudes of 1700–1900 m. They occupy the driest sites – mountain slopes of the southern (south-western and south-eastern) aspects, with an inclination of 5–48° and loamy, rocky, well-drained soils.

The tree layer is usually birch-pine (*Pinus sylvestris* var. *hamata*, *Betula pubescens* var. *litwinowii*) mixed. Its coverage is 30–70 % and the mean height is 10–24 m (depending on the age of the trees). Fir (*Abies nordmanniana*) sometimes forms an admixture to birch and pine, but it is more common in the lower sublayer since it is characterized by low vitality. The shrub layer is dominated by *Daphne mezereum, Juniperus communis, Lonicera caucasica* subsp. *orientalis, Viburnum lantana*. The main floristic peculiarity of the well-developed grass layer is the significant participation of subalpine tall-forb species – *Aconitum orientale, A. nasutum, Astrantia pontica, Euphorbia macroceras, E. oblongifolia, Lapsana communis* subsp. *grandiflora, Linum hypericifolium*. In addition, unlike the previous association, there are few boreal species here. The moss layer is poorly developed or absent.

The association includes two variants. The var. *Centaurea phrygia* subsp. *abbreviata* (syntaxon 8 in Table 2) contains more subalpine species (*Linum hypericifolium, Thymus nummularius, Centaurea phrygia* subsp. *abbreviata, Lomatocarum alpinum, Viburnum lantana, Euphorbia oblongifolia, Alchemilla orthotricha, Asplenium viride*) while the var. *Geranium robertianum* (syntaxon 7 in Table 2) includes more forest plants (*Cardamine bulbifera, Geranium robertianum, Hesperis matronalis, Oxalis acetosella, Urtica dioica*).

The floristic originality of the described two new associations (and four variants) in comparison with other syntaxa of pine grass forests from the Caucasian mountain system is demonstrated on the dendrogram created using the Jaccard coefficient (Median method) (Fig. 3). Cluster A (Fig. 3) represents pine and birch-pine moderately mesophilous forests of the alliance *Bupleuro polyphylli–Pinion sylvestris* Ermakov et al. 2020. It includes three East Caucasian associations – *Carici albae–Pinetum sylvestris* Ermakov et al. 2019 (cluster A1), *Ranunculo caucasicae–Pinetum sylvestris* Ermakov et al. 2020 (cluster A2) and *Viburno lanatae–Pinetum sylvestris* Ermakov et al. 2019 (cluster A3).

Table 1. Syntaxa of the *Brachypodio–Betuletea* in the Western Caucasus

Altitude (m)	1894	1949	1908	1870	1836	1836	1834	1897	1878	1875	2012	2015	2133	2070	2031	2172	2123	2174	2137	2133	2136	2099	1825	1835	1845	1735	1833	1829	1825	1820	1847	1720	1760	1725	1891	1675	1755	1785	1761	1769	1755	1750	1815
Aspect (°)	180	180	150	210	180	200	170	200	180	187	160	190	180	210	190	180	180	180	210	220	230	170	225	190	270	245	225	245	90	270	245	230	137	233	278	0	290	273	304	25	52	250	0
Inclination (°)	25	40	17	15	40	25	25	12	20	27	30	20	25	17	25	25	39	20	30	20	35	28	17	7	20	14	15	21	24	28	48	23	10	25	11	0	20	5	6	20	45	41	0
Cover of tree layer (%)	40	40	50	50	40	50	55	60	60	60	60	60	65	60	50	50	55	60	60	60	60	50	50	40	40	50	30	40	70	70	40	50	60	40	50	40	50	70	40	60	50	60	60
Cover of shrub layer (%)	20	7	15	7	12	10	5	7	10	12	5	3	5	3	3	5	7	5	8	4	3	4	2	5	1	20	5	10	7	2	15	25	5	30	10	5	5	10	7	5	10	5	50
Cover of herb layer (%)	70	70	80	80	80	75	80	80	80	75	70	70	80	70	70	70	75	70	70	80	80	75	80	75	80	70	55	85	85	75	45	75	75	50	60	90	90	80	70	80	50	80	30
Cover of moss layer (%)	2	2	3	5	5	2	2	5	5	3	3	3	3	0	3	3	3	0	3	3	3	0	10	24	0	5	0	0	50	0	0	40	50	0	0	0	5	5	10	2	5	5	0
Relevé no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
DS (Diagnostic species) Ass. *Bistorto carneae–Pinetum sylvestris*																																											
Pimpinella rhodantha (hl)	1	2	2	+	2	2	2	1	2	1	2	1	+	2	.	2	2	2	2	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.					
Campanula lactiflora (hl)	.	+	+	+	+	.	+	1	1	.	1	1	1	1	1	+	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.					
Vaccinium myrtillus (hl)	2	.	2	1	.	1	1	.	2	.	2	1	1	.	+	2	2	2	2	2	+	+	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	3				
Bistorta carnea (hl)	+	.	2	1	+	.	+	+	+	.	+	.	+	.	1	+	+	.	.	1	1	+	.	.	.	.	.	.	.	.	r	.	.	r	.	.	.	.	.	.				
Luzula multiflora (hl)	2	.	+	+	.	.	.	+	+	+	+	+	.	.	.	+	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Poa longifolia (hl)	.	.	.	1	.	.	+	.	+	.	+	.	1	+	2	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Aconitum cymbulatum (hl)	.	.	.	.	+	+	.	.	+	+	.	1	1	2	2	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Achillea biserrata (hl)	+	.	.	.	.	1	.	.	+	.	1	2	.	1	+	1	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.				
Anthriscus schmalhausenii (hl)	.	+	.	+	+	.	.	.	+	+	.	+	+	+	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.				
Pyrola rotundifolia (hl)	+	.	+	+	.	+	.	.	.	.	+	1	.	.	2	1	1	2	+	.	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Anthoxanthum odoratum (hl)	+	+	.	.	.	.	+	.	.	+	.	.	.	.	.	.	+	2	2	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Var. *Rhododendron luteum*																																											
Athyrium filix-femina (hl)	+	+	.	1	.	2	1	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.				
Rhododendron luteum (s1)	2	.	2	.	2	2	.	2	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Psephellus dealbatus (hl)	.	2	1	1	2	1	1	.	1	+	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Trifolium canescens (hl)	.	1	.	.	2	1	1	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	r	.	.	.	.	.	.				
Dianthus caucaseus (hl)	.	.	+	.	+	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Tragopogon reticulatus (hl)	.	r	+	+	+	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Var. *Avenella flexuosa*																																											
Avenella flexuosa (hl)	.	+	.	.	r	.	+	.	.	.	2	.	.	2	1	2	2	2	2	2	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Milium schmidtianum (hl)	.	.	.	.	.	.	.	.	.	.	1	1	+	1	2	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	+	.	1	2	.	.			
Myosotis alpestris (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Orthilia secunda (hl)	.	.	+	.	.	.	.	.	.	.	.	+	+	.	+	1	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.			
DS Ass. *Aconito nasuti–Pinetum sylvestris*																																											
Aconitum orientale (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	+	+	+	.	+	.	+	1	1	+	.	1	1	.	.	+		
Aconitum nasutum (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+	+	+	+	+	.	+	+	+	r	+	+	r	+	+	+	+	.	.		
Lonicera caucasica subsp. *orientalis* (s1)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	.	2	.	1	2	1	+	+	1	2	+	1	1	+	+	+	.	1	r		
Daphne mezereum (s1)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+	+	R	.	.	+	+	+	1	.	1	r	1	+	r	+	.		
Dryopteris filix-mas (hl)	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	+	.	.	.	.	.	.	.	+	.	+	r	+	+	.	r	.	.	.	+	2	+	2	+	1	.	r	+		
Juniperus communis (s1)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	1	+	.	+	+	2	.	.	+	+	2	r	.	.	.	.	.			
Swertia iberica (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	r	+	r	+	.	.	.	.	r	.	2	+	+	.	.	.	.			
Euphorbia macroceras (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	+	.	.	1	+	+	+	.	+	2	.	+	+	2	+	.		

Table 1 (continued)

Var. *Centaurea phrygia* subsp. *abbreviate*																																											
Linum hypericifolium (hl)	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	+	.	+	+	+	+	.	+	r	+	.	+	.	.	.	+	+	.	.	.	.	.	.	.
Thymus nummularius (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	r	+	.	+	r	r	.	r	.	.	.	.	+	.	.	.	.	.	.	.
Centaurea phrygia subsp. *abbreviata* (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	r	+	+	r	.	.	+	.	.	r	.	+	.	+	.	.	.	.
Lomatocarum alpinum (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	+	1	+	2	.	.	.	1	.	1	.	.	+	.	.	.	.	1
Viburnum lantana (s1)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	1	r	r	.	.	.	+	.	.	.	.	.	+	.	.	.	.
Euphorbia oblongifolia (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	r	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Alchemilla orthotricha (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+	+	.	.	.	.	.	+	.	.	.	.	.	.	.
Asplenium viride (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	+	+	.	.	.	.	.	+	.	.	+	.	.	.	.	.
Var. *Geranim robertianum*																																											
Geranium robertianum (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	+	r	+	+	+	.	+	.
Lapsana communis subsp. *grandiflora* (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	r	.	.	.	2	1	+	.	+	+	+	2	+	+	1	r	1	.
Urtica dioica (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	+	+	+	2	+	.	.
Gentiana asclepiadea (hl)	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	+	.	.	.	2	.	+	.	.	.	.	.	.	.	1	r	.	1	1	.	r	r
Hesperis matronalis (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	r	.	r	+	.	.	.	.	r	.	.	.
Alchemilla retinervis (hl)	.	.	.	+	.	.	.	+	+	.	r	.	.	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	r	+	.	.	r	1	.	1	.	.	.	.	.	.
Arafoe aromatica (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	r	.	2	.	+	+	.	.	.	+	+	.
Oxalis acetosella (hl)	.	.	.	+	.	1	+	.	.	+	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	1	+	.	.	2	1
Cardamine bulbifera (hl)	.	.	.	.	.	.	.	.	.	+	.	2	2	+	2	+	.	.	.	.	.	2	.	.	.	.	.	.	.	+	.	+	.	+	.	1	+	.	r	.	+	+	.
DS All. *Asyneumo campanuloidis–Pinion sylvestris*																																											
Asyneuma campanuloides (hl)	.	+	+	+	+	+	+	1	1	.	1	1	2	1	2	+	+	.	.	1	2	2	.	+	+	.	r	+	.	1	+	1	.	+	+	.	+	r	+	.	+	+	.
Phedimus stoloniferus (hl)	r	.	+	r	1	.	.	+	1	+	.	.	1	1	2	.	.	.	.	1	1	.	+	.	.	+	.	r	.	.	.	.	+	.	.	.	+	.	+	.	.	.	.
Sorbus aucuparia (t2)	2	2	2	2	2	2	2	.	2	.	2	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	2	.	.	2
Sorbus aucuparia (s1)	2	2	.	.	2	.	1	2	1	+	2	1	.	1	+	2	2	1	2	+	+	1	.	r	1	+	.	r	r	r	+	.	1	.	r	.	.	.	.	+	+	+	+
Hieracium prenanthoides subsp. *hypoglaucum* (hl)	.	.	.	.	.	.	+	.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	r	r	+	+	+	r	+	1	r	.	.	+	+	.	r	+	.	+	.	+	.
Hieracium lachenalii subsp. *lachenalii* (hl)	1	.	+	+	.	+	+	.	+	+	2	2	1	2	+	2	2	2	2	.	1	2	r	.	.	+	.	.	.	.	+	.	+	r	+	r	.	+	.	.	.	.	r
Selinum physospermifolium (hl)	+	.	+	2	+	2	.	+	1	.	.	.	+	.	+	.	.	.	+	.	.	.	+	.	.	+	r	r	.	.	.	1	.	r	r	+	2	.	+	1	.	r	.
Cirsium obvallatum (hl)	.	.	.	.	.	.	.	+	.	.	+	+	.	.	+	.	.	.	.	1	.	+	.	+	+	.	r	.	r	+	+	1	.	r	.	+	.	.	r	.	r	.	.
Acer heldreichii subsp. *trautvetteri* (s1)	1	1	2	1	.	.	.	1	.	+	.	+	.	.	+	.	.	+	+	.	.	.	.	r	.	+	.	+	.	.	.	.	+	+	.	.	.	.	+	+	.	.	.
Aquilegia olympica (hl)	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	+	.	.	.	1	2	+	.	+	+	.	+	+	+	.	.	.	.	.	+	.	.	r	r	.	.	.	.
Lilium monadelphum (hl)	.	.	+	.	+	.	+	+	.	.	+	.	.	.	+	.	.	.	.	.	+	.	1	.	1	.	r	r	.	2	.	+	+	1	.	1	+	.	+	.	.	.	.
Vicia balansae (hl)	.	.	.	.	.	.	.	.	.	.	+	2	2	1	2	+	2	.	1	2	2	1	1	+	+	+	+	+	+	1	1	+	+	+	+	1	r	.	+	+	1	.	.
Campanula latifolia (hl)	.	.	.	.	.	.	.	.	.	.	.	+	.	.	r	+	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	+	.	r	.	+	+	.	.	1	+	r	.
DS Ord. *Alchemillo sericatae–Pinetalia sylvestris*																																											
Astrantia maxima (hl)	+	.	.	.	+	+	.	+	.	+	2	2	2	1	2	2	2	2	2	2	2	2	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	+	+	2	.	.
Astrantia pontica (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	1	1	3	2	2	3	+	r	3	3	3	.	+	3	2	.	.	.	2	+
Chaerophyllum aureum (hl)	.	1	+	2	.	2	.	+	.	+	+	.	1	.	1	.	+	.	.	1	.	+	+	1	1	+	+	+	+	1	1	1	+	+	+	1	+	+	+	1	2	+	+
Polygonatum verticillatum (hl)	2	.	2	2	1	2	+	.	+	+	.	2	1	1	2	1	.	.	.	+	1	1	2	+	2	3	2	2	1	+	3	2	+	+	3	1	+	1	2	+	1	+	.
Ranunculus caucasicus (hl)	+	.	.	+	.	+	.	+	+	.	.	.	+	.	+	+	+	.	+	2	2	+	+	+	+	.	r	.	.	+	.	.	.	.	r	.	.	.	.	r	+	.	.

Table 1 (continued)

Valeriana tiliifolia (hl)	+ . . + + + . + . +	2 + 2 2 2 2 2 2 2 2 2 2	+ . + + + . 1	1 2 1 2 + + 3 + 2 + 1 . + +
Campanula collina (hl)	+ . . . 1	r 1 1 2 . + 1 2 2 1 1 1	r . . . . . +	+ + . . . r + ... r
Cephalaria gigantea (hl)	2 . 2 . 2 . + . . +	2 1 . . . . . + . 1 2 1	2 2 2 + 1 r 1	. + + 1 + r . + + + . . . +
Betonica macrantha (hl)	+ . + . . + + . . +	. . . 1 + . + . . + 1 .	+ 2	+ + . . . r + . . . r + . .
Galium valantioides (hl)	+ . . + + + + + . +	. . . .	2 + + 2 1 + +	. + . + . . + . + ... +
Cruciata laevipes (hl)	. . + + + . + . + +	. . . + 1 . . . . + . 1	. + ...	+ . . . .
	DS Cl. *Brachypodio pinnati–Betuletea pendulae*			
Pinus sylvestris var. *hamata* (t1)	3 3 4 4 3 4 4 3 4 4	4 3 4 4 3 4 3 4 4 4 4 4	2 + 2 3 + 1 2	3 2 3 3 3 . . . 2 + . r 3 1
Pinus sylvestris var. *hamata* (t2)	2 . . . 2 . 2 2 2 2	2 2 2 2 3 2 . 2 2 2 2 2	. . . + 2 . 1	. + ...
Pinus sylvestris var. *hamata* (s1)	. . . . . . 1 1 2 1	. . . .	. + . + 1 + +	. + ... + ...
Betula pubescens var. *litwinowii* (t1)	. . . .	. . . .	. . + 2 1 3 3	. . . 1 . 3 2 3 1 2 3 4 . 2
Betula pubescens var. *litwinowii* (t2)	. 1 . . . + + . 1 .	. 2 . . 2 . . . . 2 1 +	2 3 1 2 3 . +	. . . . . 1 . 2 . . 2 . . .
Betula pubescens var. *litwinowii* (s1)	. . . . . . + . . .	. . . . r r + . .	1 + . 1 . 1 .	. . . . . 1 + + . . . 2 . .
Calamagrostis arundinacea (hl)	3 3 2 3 2 3 2 2 2 2	2 3 2 2 3 2 2 3 2 3 3 3	3 2 4 3 2 2 2	3 3 1 . 1 2 + 1 1 2 2 3 2 2
Fragaria vesca (hl)	1 1 2 2 2 . 1 1 2 +	. . . . + ...	. 1 + . + + +	+ + 2 + + . . + + . . . + r
Geranium sylvaticum (hl)	2 . 2 2 . 2 1 2 2 1	2 2 2 1 2 . 2 2 2 2 2 2	r + ...	. + + . + + + + . + . + . .
Pulmonaria mollis (hl)	1 . 2 2 + 2 2 1 + 1	2 2 . + 1 1 + . 1 + 1 1	. . . .	. . . . + . .
Brachypodium pinnatum (hl)	2 2 2 2 3 2 2 2 2 2	. . . .	2 + 1 . 2 . .	1 . . 2 . . . .
Solidago virgaurea (hl)	+ 2 2 2 2 2 1 1 1 +	. . . . . . + ...	+ . + 1 + + +	+ . 1 2 + + . . 2 2 + r + +
Senecio propinquus (hl)	1 . + 2 + 1 1 1 . +	2 2 2 2 2 2 2 2 2 2 1 2	. . . + . + .	. . . + . r + . 1 + . . + +
Vicia cracca (hl)	+ + 1 . 1 . + + + .	. + ... + 1 . +	+ . . r . r .	. + . . . r . + . r . . . .
Heracleum asperum (hl)	+ . r + . . + . + .	r + + . . r . . . . + +	r . 1 + + + .	+ r 1 + . + + + + + + + r .
Rubus saxatilis (hl)	+ . 1 . . . . . + +	. . . .	+ 1 + 1 + + +	+ 1 . . 1 2 + + . . . 2 . +
Thalictrum minus (hl)	. . + + . . . + . +	. . . + ...	. . . r . . .	. . . + . + + . + ... +
Anemonastrum fasciculatum (hl)	1 . 2 2 1 2 + 1 1 +	1 + 1 + + 1 1 . . 2 2 1	3 + + . + + +	. r . . . . + r + . .
Angelica sylvestris (hl)	. . . .	. . . .	. . . . . + .	. . + ... + r r . .
Crepis sibirica (hl)	. . . .	. + . . + + ...	. 1 . . r . r	. . . .
Primula veris subsp. *macrocalyx* (hl)	. . . . + + .	. . + ...	. r . . . r .	. . . .
Salix caprea (t2)	. . . .	. . . .	. + . + + . 2	. . . . . . 1 1 + . 1 1 . .
Salix caprea (s1)	. . . .	. . . .	. . . . + . .	. . . + r . . . .
Прочие виды:				
Abies nordmanniana (t1)	. . . .	2 . . . . 2 2 2 2 . . .	. . . . . + .	. . . . . . + . 1 . . . + 1
Abies nordmanniana (t2)	2 2 2 2 . 2 2 2 2 2	2 2 2 . 2 2 2 2 2 . . 2	1 . . + . . .	. . 2 2 + + . 2 1 + . . 2 .
Abies nordmanniana (s1)	. 2 1 2 1 2 2 1 1 1	2 1 2 1 1 2 2 1 2 2 + 2	+ . + + . . .	. . + . + . . 1 + . r . 2 1
Abies nordmanniana (hl)	. 1 . 1 . 1 + + . .	. . . . 1	. . . .	. . . . . + . . . + ...
Fagus orientalis (t2)	+ . 1 2 . 2 1 . 1 2	. . . .	. . . . + . .	. . . .
Fagus orientalis (s1)	. . . .	. . . .	r r r r r r +	. . . + . r . . . . r . r r
Picea orientalis (t2)	. 2 . . . 2	. . . . 1 . 2 . .	. . . .	. . . .
Picea orientalis (s1)	2 . . . . 2 + . . +	. . . . 2 + . . .	. . . .	. . . .

Table 1 (continued)

Poa nemoralis (hl)	+	+	.	+	.	1	.	+	+	+	+	1	2	2	1	1	1	1	1	2	.	2	.	.	.	1	.	.	.	.	.	+	+	+	.	.	+	+	.	.	.	+	2
Plagiomnium affine (ml)	.	.	.	1	.	+	.	+	1	.	1	+	1	.	.	1	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.
Brachythecium reflexum (ml)	.	.	.	1	.	.	.	+	.	+	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rubus idaeus (s1)	.	+	.	1	1	.	.	+	+	.	.	+	1	+	1	.	+	.	.	.	.	.	.	+	.	+	.	+	r	.	.	2	.	.	+	.	.	+	+	.	+	.	.
Silene vulgaris (hl)	.	.	+	.	.	.	.	+	+	.	.	+	+	.	.	.	+	.	.	+	+	+	.	.	.	.	.	.	+	+	.	.	.	.	.	r	.	.	+	+	+	.	.
Rhytidiadelphus triquetrus (ml)	+	2	.	.	.	.	.	1	.	r	.	.	.	.	.	1	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula forsteri (hl)	+	.	.	+	.	+	.	+	.	.	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Galium odoratum (hl)	.	.	+	+	.	1	+	+	.	.	.	.	.	.	1	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	2	3	.	.	+	.
Stellaria holostea (hl)	.	.	+	+	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	+	.	.	.	.
Bromopsis variegatus (hl)	.	.	+	.	2	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Thymus praecox subsp. *caucasicus* (hl)	.	.	.	.	1	1	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dolichorrhiza renifolia (hl)	.	.	.	.	.	+	.	.	+	.	.	.	.	.	1	r	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Veratrum lobelianum (hl)	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	r	.	.	.	.	+	.	+	+	.	.	.	.	.	.	.	+	.	.	r	+	.	.	+	.	+	.	.
Ranunculus cappadocicus (hl)	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.
Chamaenerion angustifolium (hl)	.	.	.	.	+	.	.	+	.	.	.	.	.	+	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Salix caucasica (s1)	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Alchemilla persica (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	r	1	.	.	.	.	.	.	+	.	.	.	.	.	+	1	.	.
Pojarkovia pojarkovae (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	r	.	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Euonymus leiophloeus (s1)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	1	+	.	.	.	+	+	.	.	.	1	.	.	.	.	.
Festuca drymeja (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	2	1	.	.	r	1
Cotoneaster integerrimus (s1)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	r	.	.	.	1	.	.	.	.	.	.	.	.
Carex digitata (hl)	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	r	.	.	.	+	.	r	.	.	.	.	.	.	.	.
Eleutherospermum cicutarium (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	r	+	+	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.
Tortella tortuosa (ml)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.
Homalothecium philippeanum (ml)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.
Galium album (hl)	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	+	.	+	.	+	.	.	.	.	+	.	.	.	.	.	.	.	+	.
Cicerbita racemosa (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	+	2	.	.	+	.	.	+	.	.	.	.	.	.	.
Poa tanfiljewii (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	.	.	.	+	.	.	.	.	+	.	.
Polystichum lonchitis (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	r	.	.	.	.	.	.	r	+	.	r	+	+	.	.	.
Lophiolepis czerkessica (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	+	.	+	.	.	.	+	.	.	.	.	.	.
Geranium pratense (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.
Dactylis glomerata (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	1	.	.	+	.	.	.	.	.	.
Chiastophyllum oppositifolium (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	+	.	1	.	.	.
Ribes biebersteinii (s1)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	+	.	.	+	.	.	.
Carex sylvatica (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	+	.	.	+	.	.	.	.	.	.
Epilobium montanum (hl)	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	r	r	r	.
Clinopodium grandiflorum (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	+	.	.	.	r	.	.	.	.	+	+
Asperula taurina (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	2	.	+	+	.	.	.

Table 1 (continued)

Polygonatum multiflorum (hl)	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	+	.	.	.	.	+
Symphytum asperum (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	+	.	.	.
Geum rivale (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	r	.	.	+	.	.	.	.	.	.
Festuca valesiaca (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	r	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Vaccinium vitis-idaea (hl)	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pleurozium schreberi (ml)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Goodyera repens (hl)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+
Dicranum scoparium (ml)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.

Rare species: *Acer heldreichii* subsp. *trautvetteri* (t1) – 32(r), 39(+), *A. heldreichii* subsp. *trautvetteri* (t2) – 38(2), 40(+), *A. platanoides* (s1) – 24(r), 34(+), *A. pseudoplatanus* (s1) – 42(r), *A. pseudoplatanus* (t2) – 7(+), 9(+), 37(+), *Aconitum anthora* (hl) – 30(r), *Alchemilla caucasica* (hl) – 43(+), *Xanthogalium tatianae* (hl) – 35(r), *Cota melanoloma* (hl) – 27(+), 32(+), *Anthyllis vulneraruia* subsp. *boisseri* (hl) – 23(r), *Arabis nordmanniana* (hl) – 37(1), 38(+), *Argyrolobium biebersteinii* (hl) – 5(+), 7(+), 9(+), *Aruncus vulgaris* (hl) – 37(+), 40(r), *Asplenium adiantum–nigrum* (hl) – 38(r), *A. ruta–muraria* (hl) – 34(r), *A. scolopendrium* (hl) – 37(+), *A. trichomanes* (hl) – 34(+), 37(+), *Astragalus glycyphyllos* (hl) – 33(1), 36(r), *Berberis vulgaris* (s1) – 35(+), *Betula pubescens* var. *litwinowii* (hl) – 2(+), *Briza media* (hl) – 23(+), *Bupleurum polyphyllum* (hl) – 7(+), 20(+), 23(+), 27(+), 38(r), *Campanula sp.* (hl) – 2(+), 3(+), *C. tridentata* (hl) – 30(+), *Cardamine pectinata* (hl) – 27(r), *Carduus adpressus* (hl) – 24(+), 27(+), 30(r), *Caucasalia pontica* (hl) – 12(+), 30(+), 41(+), *Cephalaria calcerea* (hl) – 1(+), 3(+), 9(+), *Chaerophyllum rubellum* (hl) – 27(r), 41(r), *Cicerbita prenanthoides* (hl) – 40(+), *Cirsium vulgare* (hl) – 31(+), *Clinopodium vulgare* (hl) – 25(r), 33(r), 37(+), *Crepis caucasica* (hl) – 30(+), 39(+), *Cystopteris fragilis* (hl) – 26(r), 29(r), 40(+), *Daphne glomerata* (s1) – 27(r), *D. mezereum* (hl) – 7(+), 16(r), *Delphinium speciosum* (hl) – 27(+), *Dryopteris carthusiana* (hl) – 33(+), *D. expansa* (hl) – 9(+), 12(+), 17(+), *Epipactis helleborine* (hl) – 24(r), *Erysimum aureum* (hl) – 38(+), 43(+), *Eurhynchium angustirete* (ml) – 30(1), *Festuca altissima* (hl) – 33(1), *F. gigantea* (hl) – 36(r), *Geranium gracile* (hl) – 37(+), *G. rotundifolium* (hl) – 42(r), *Geum latilobum* (hl) – 38(+), 40(+), *Grimmia sp.* (ml) – 23(1), *Gymnadenia conopsea* (hl) – 23(r), *Hypericum hirsutum* (hl) – 36(r), *Hypnum cupressiforme* (ml) – 23(1), 26(1), *H. pallescens* (ml) – 4(+), 8(+), 9(+), 12(1), *Jacobaea othonnae* (hl) – 40(r), *Juniperus sabina* (s1) – 43(r), *Kemulariella caucasica* (hl) – 23(+), 39(+), 40(+), *Knautia arvensis* (hl) – 4(+), 30(+), *Koeleria cristata* (hl) – 30(r), 37(2), *Lactuca muralis* (hl) – 32(1), *Lamium album* (hl) – 38(+), *Lathyrus aureus* (hl) – 24(1), *L. pratensis* (hl) – 27(+), 36(r), *Lescuraea incurvata* (ml) – 37(1), 40(1), *L. saxicola* (ml) – 23(1), *Libanotis pyrenaica* subsp. *pyrenaica* (hl) – 23(r), 37(r), *Lotus corniculatus* (hl) – 23(r), 37(r), *Mnium spinosum* (ml) – 40(1), 41(1), *M. thomsonii* (ml) – 41(1), *Moneses uniflora* (hl) – 42(+), *Myosotis sylvatica* (hl) – 27(r), 40(2), *Neottia nidus–avis* (hl) – 22(r), 33(r), *Oxyrrhynchium hians* (ml) – 40(1), *Pedicularis atropurpurea* (hl) – 39(+), *Pentanema orientale* (hl) – 10(+), 12(+), 21(+), *Petasites albus* (hl) – 13(+), 31(+), *Phleum pratense* (hl) – 23(r), *Picea orientalis* (t1) – 19(2), *Pimpinella saxifraga* (hl) – 24(r), *Picea orientalis* (hl) – 3(+), 7(+), 9(+), *Platanthera chlorantha* (hl) – 8(+), 17(1), *Poa alpina* (hl) – 23(+), 25(+), 28(r), *Polygonatum odoratum* (hl) – 43(+), *Polypodium vulgare* (hl) – 38(+), 43(1), *Populus tremula* (t1) – 26(+), *P. tremula* (s1) – 12(+), 26(1), *Potentilla micrantha* (hl) – 7(+), 9(+), 15(+), 16(1), *Prunella vulgaris* (hl) – 35(+), 36(+), *Prunus laurocerasus* (s1) – 26(1), 37(1), *Pyrola chlorantha* (hl) – 41(r), *Ranunculus oreophilus* (hl) – 23(+), *Rhododendron caucasicum* (s1) – 40(1), *Rhytidium rugosum* (ml) – 5(+), 9(+), *Ribes alpinum* (s1) – 26(+), 30(r), 38(+), *Rosa canina* (s1) – 34(+), *R. oxyodon* (s1) – 33(1), *R. pulverulenta* (s1) – 37(r), *Rosa sp.* (s1) – 27(+), 29(+), 36(+), *Rubus caucasicus* (s1) – 42(+), *R. hirtus* (s1) – 43(+), *R. serpens* (s1) – 36(+), *Rumex acetosa* (hl) – 39(+), 40(+), *R. alpestris* (hl) – 27(r), 31(+), 41(+), *R. alpinus* (hl) – 36(r), 37(r), *Sabulina biebersteinii* (hl) – 43(+), *Salvia glutinosa* (hl) – 34(+), *Saxifraga rotundifolia* subsp. *rotundifolia* (hl) – 38(+), 39(+), 40(+), *Scabiosa bipinnata* (hl) – 38(+), *Sciuro–hypnum reflexum* (ml) – 40(1), *Scrophularia scopolii* (hl) – 30(r), *Selinum alatum* (hl) – 30(r), 36(+),*Trifolium polyphyllum* (hl) – 30(r), *Tschulaktavia saxatilis* (hl) – 5(+), 8(+), *Silene saxatilis* (hl) – 25(+), 37(r), 43(+), *Sorbus aucuparia* (t1) – 38(1), 48 (+), 41(r), *S. torminalis* (t2) – 33(+), *Stachys balansae* (hl) – 24(+), *Syntrichia calcicola* (ml) – 23(1), *Taxus baccata* (s1) – 29(+), *Tephroseris cladobotrys* (hl) – 40(+), *Thalictrum simplex* (hl) – 32(+), *T. triternatum* (hl) – 41(+), *Tilia dasystyla* subsp. *caucasica* (t2) – 37(+), *Ulmus glabra* (s1) – 38(+), *Vaccinium arctostaphylos* (s1) – 1(+), 10(+), 23(1), *Valeriana colchica* (hl) – 12(2), 15(r), 39(+), *Veronica filiformis* (hl) – 30(r), *V. gentianoides* (hl) – 27(r), *V. officinalis* (hl) – 2(+), 9(+), 13(+), *Vicia cassubica* (hl) – 1(+), 3(+), *Viola alba* (hl) – 2(1), 8(+), 9(+), *V. reichenbachiana* (hl) – 42(r).

Notes: The relevés no. 1-22 were performed by N. Ermakov in the Krasnodarskiy kray, the Laba river basine. The relevés no. 23-43 were performed by Ju. Akatova in the Republic of Adygeya, the Belaya river basin. Dates: relevés no. 1–4 – 30 VI 2018; 5, 6, 11, 16–19 – 01 VII 2018; 7–10 – 12 VII 2018; 12–15, 20–23 – 02 VII 2018; 23–20 VII 2023; 24, 25, 26, 27, 29–08 IX 2022; 28, 35 – 3 IX 2023; 30–25 VIII 2022; 31, 37, 41, 42 – 29 VII 2023; 32, 34 – 26 VII 2023; 33, 38 – 24 VII 2023; 36–19 VII 2023; 39, 40 – 2 IX 2023; 43–15 VIII 2023.

Field numbers of relevés: 1 – 47NE18, 2 – 48NE18, 3 – 49NE18, 4 – 51NE18, 5 – 53NE18, 6 – 54NE18, 7 – 127NE18, 8 – 128NE18, 9 – 129NE18, 10 – 130NE18, 11 – 59NE18, 12 – 66NE18, 13 – 62NE18, 14 – 60NE18, 15 – 65NE18, 16 – 58NE18, 17 – 55NE18, 18 – 57NE18, 19 – 56NE18, 20 - 63NE18, 21 – 64NE18, 22 – 61NE18, 23 – 760/485, 24 – 773/446, 25 – 758/444, 26 – 771/528, 27 – 759/445, 28 – 780/533, 29 – 757/443, 30 – 756/432, 31 – 769/504, 32 –

763/491, 33 – 762/490, 34 – 764/492, 35 – 779/532, 36 – 774/482, 37 – 775/495, 38 – 761/489, 39 – 778/530, 40 – 777/529, 41 – 776/503, 42 – 767/496, 43 – 770/506.

Localities: the Skirda-Yatyrgvarta mountain ridge – 1 – 22, coordinates: 1 – 43°52'39.1"N, 40°40'15.7"E; 2 – 43°52'40.2"N, 40°40'17"E; 3 – 43°52'41.4" N, 40°40'18.8"E; 4 – 43°524'2.3"N, 40°40'27.8"E; 5 – 43°52'40"N, 40°40'30.7"E; 6 – 43°52'39"N, 40°40'32.6"E; 7 – 43°51'21.7"N, 40°35'26.1"E; 8 – 43°52'40.2"N, 40°40'34.1"E; 9 – 43°52'39.8"N, 40°40'31.9"E; 10 – 43°52'36.5"N, 40°40'32.1"E; 11 – 43°51'23.8"N, 40°35'29.9"E; 12 – 43°51'20.2"N, 40°35'24.7"E; 13 – 43°51'17.1"N, 40°35'45.7"E; 14 – 43°51'15.5"N, 40°35'41.8"E; 15 – 43°51'19.7"N, 40°35'30.2"E; 16 – 43°51'22.5"N, 40°35'31.9"E; 17 – 43°51'25.8"N, 40°35'29.6"E; 18 – 43°51'25.4"N, 40°35'36.8"E; 19 – 43°51'24.5"N, 40°35'32.5"E; 20 – 43°51'16.4"N, 40°35'48.3"E; 21 – 43°51'16.7"N, 40°35'48.4"E; 22 – 43°51'16.7"N, 40°35'43.1"E; the Lagonakskoye upland: 23 – 43°58'29"N, 39°57'5"E; 24 – 44°3'32"N, 40°1'20"E; 25 – 44°3'34"N, 40°1'19.7"E; 26 – 44°3'32.01"N, 40°1'07.95"E; 27 – 44°1'30"N, 39°55'9"E; 28 – 44°3'32.8"N, 40°1'18.2"E; 29 – 44°03'29.52"N, 40°01'19.49"E; 30 – 44°1'51.1"N, 39°55'18.1"E; 31 – 44°1'30"N, 39°55'9"E; 32 – 44°2'31"N, 39°55'0.17"E; 33 – 44°4'58"N, 40°0'22"E; 34 – 44°2'28.79"N, 39°55'2.53"E; 35 – 44°3'03.02"N, 40°1'38.15"E; 36 – 43°56'24"N, 39°55'26"E; 37 – 44°2'47"N, 39°55'9"E; 38 – 44°4'42"N, 40°0'38"E; 39 – 44°3'33.72"N, 40°1'00.06"E; 40 – 44°3'31.528"N, 40°1'03.22"E; 41 – 44°1'35"N, 39°55'12"E; 42 – 44°2'48"N, 39°55'8"E; 43 – 44°04'52.1"N, 40°01'1.27"E.

Designations: t1 – tree layer, higher sublayer; t2 – tree layer, lower sublayer; s1 – shrub layer; hl – grass layer; ml – moss layer.

Table 2. Synoptic table of pine (*Pinus sylvestris* var. *hamata*) forest syntaxa from the Northern Caucasus

Syntaxon No.	1	2	3	4	5	6	7	8	9
D. S. (Diagnostic species)									
Ass. *Viburno lanatae–Pinetum sylvestris*									
Taxus baccata	V	.	.	.	.	.	.	I	.
Oxalis acetosella	V	.	.	.	II	I	II	.	.
Daphne glomerata	IV	.	.	.	.	.	I	.	.
Asplenium ruta-muraria	IV	.	I	.	.	.	I	.	III
Asplenium trichomanes	IV	I	I	.	.	.	I	.	II
Euonymus verrucosus	IV	II	I	.	.	.	.	.	.
Carex caryophyllea	III	.	II	.	.	.	.	.	.
D. S. Ass. *Carici albae–Pinetum sylvestris*									
Carex alba	.	V	.	.	.	.	.	.	.
Tanacetum akinfiewii	.	III	.	.	.	.	.	.	.
Briza media	.	III	.	.	.	.	.	I	.
Centaurea phrygia subsp. *salicifolia*	.	III	.	.	.	.	.	.	II
D. S. Ass. *Ranunculo caucasicae–Pinetum sylvestris*									
Rosa spinosissima	II	II	IV	II	.	.	.	.	.
Galium rubioides	II	II	IV	.	.	.	.	.	.
Psephellus czirkejensis	I	II	IV	.	.	.	.	.	.
Gentiana cruciata	I	I	III	.	.	.	.	.	.
Origanum vulgare	.	I	III	II	.	.	.	.	I
D. S. Ass. *Calamagrostio caucasicae–Pinetum sylvestris*									
Bromopsis variegatus	.	II	I	V	II	.	.	.	.
Galium verum	I	I	III	V	.	.	.	.	.
Campanula stevenii	.	I	.	IV	.	.	.	.	.
Senecio lapsanoides	.	.	.	III	.	.	.	.	.
D. S. Ass. *Bistorto carneae–Pinetum sylvestris*									
Pimpinella rhodantha	.	.	I	.	V	V	I	.	.
Bistorta carnea	.	.	I	.	IV	IV	I	.	.
Campanula lactiflora	.	.	.	.	IV	III	.	.	.
Luzula multiflora	.	.	.	.	III	III	.	.	.
Anthriscus schmalhausenii	.	.	.	.	III	III	I	.	.
Aconitum cymbulatum	.	.	.	.	II	III	I	.	.
Ptarmica biserrata	.	.	.	.	II	III	I	I	.

Syntaxon No.	1	2	3	4	5	6	7	8	9
Var. *Rhododendron luteum*									
Psephellus dealbatus	.	.	.	.	V	II	.	II	V
Rhododendron luteum	.	.	.	.	IV	.	.	.	.
Tragopogon reticulatus	.	.	.	.	IV	.	.	.	.
Cephalaria calcarea	.	.	.	.	III	.	.	.	.
Thymus praecox subsp. *caucasicus*	.	.	.	.	III	.	.	.	.
Viola alba	.	.	.	.	III	.	.	.	.
Var. *Avenella flexuosa*									
Avenella flexuosa	.	.	II	.	II	V	.	.	.
D. S. Ass. *Aconito nasuti–Pinetum sylvestris*									
Aconitum nasutum	.	.	.	.	.	.	IV	V	.
Aconitum orientale	.	.	I	.	.	.	IV	V	.
Lonicera caucasica subsp. *orientalis*	I	I	I	.	.	.	V	IV	.
Lapsana communis subsp. *grandiflora*	.	.	.	.	.	.	V	III	.
Daphne mezereum	.	.	.	.	I	I	IV	IV	.
Dryopteris filix-mas	I	.	I	.	.	II	IV	IV	.
Euphorbia macroceras	.	.	.	.	.	.	IV	III	.
Var. *Geranium robertianum*									
Geranium robertianum	II	I	II	.	.	.	IV	.	.
Arafoe aromatic	.	.	.	.	.	.	III	I	.
Urtica dioica	.	.	II	.	.	.	III	.	.
Var. *Centaurea phrygia* subsp. *abbreviata*									
Centaurea phrygia subsp. *abbreviata*	.	.	.	.	.	.	II	V	.
Swertia iberica	.	.	.	.	.	.	II	V	.
Lomatocarum alpinum	.	.	.	.	.	.	II	V	.
Thymus nummularius	.	.	.	.	.	.	I	V	.
Festuca drymeja	.	.	.	.	.	.	II	III	.
Polystichum lonchitis	.	.	.	.	.	.	II	III	.
Pojarkovia pojarkovae	.	I	.	.	.	.	.	III	.

Table 2 (continued)

Syntaxon No.	1	2	3	4	5	6	7	8	9
D. S. Ass. *Onobrychido cornutae–Pinetum sylvestris*, All. *Onobrychido cornutae–Pinion sylvestris*, Cl. *Erico-Pinetea sylvestris*									
Onobrychis cornuta	.	.	.	.	.	.	.	.	V
Teucrium chamaedrys	.	II	II	III	.	.	.	.	V
Helianthemum nummularium	.	II	.	I	.	.	.	.	V
Androsace villosa subsp. *koso-poljanskii*	.	.	.	.	.	.	.	.	V
Cota truimfetti subsp truimfetti	.	.	.	.	.	.	.	.	V
Asperula taurina	I	II	I	III	.	.	II	.	V
Festuca varia	.	.	.	III	.	.	.	.	V
Gypsophila tenuifolia	.	I	II	.	.	.	.	.	V
Pentanema britannica	.	I	.	.	.	.	.	.	V
Salvia canescens	.	I	III	.	.	.	.	.	V
Galium brachyphyllum	II	.	.	.	.	.	.	.	V
Pulsatilla albana	.	II	IV	.	.	.	.	.	V
Scutellaria helenae	.	.	.	.	.	.	.	.	V
Thymus daghestanicus	.	I	.	.	.	.	.	.	V
Teucrium polium	.	.	.	.	.	.	.	.	IV
Berberis vulgaris	V	I	III	.	.	.	I	.	IV
Cotoneaster integerrimus	III	IV	IV	II	.	.	I	II	IV
Salvia verticillata	I	III	III	.	.	.	.	.	IV
Astragalus fissuralis	.	.	.	.	.	.	.	.	IV
Astragalus buschiorum	.	I	I	.	.	.	.	.	IV
Linum tenuifolium	.	II	.	.	.	.	.	.	IV
Euphorbia virgata	.	I	II	.	.	.	.	.	IV
Rhamnus erythroxyloides subsp. *erythroxyloides*	.	I	.	.	.	.	.	.	IV
Vincetoxicum funebre	.	.	.	.	.	.	.	.	IV
Satureja intermedia	.	.	.	.	.	.	.	.	IV
Potentilla recta	.	.	.	.	.	.	.	.	IV
Muscari pallens	.	I	I	.	.	.	.	.	IV
Seseli alexeenkoi	.	.	.	.	.	.	.	.	IV
Lomelosa gumbetica	.	I	.	.	.	.	.	.	IV
Dracocephalum austriacum	.	.	.	.	.	.	.	.	III
Carex humilis	II	III	IV	I	.	.	.	.	III
Spiraea hypericifolia	.	II	II	.	.	.	.	.	III
Psephellus boissieri	.	I	.	.	.	.	.	.	III
Selaginella helvetica	.	I	I	I	.	.	.	.	III
Jurinea ruprechtii	.	.	.	.	.	.	.	.	III
Scorzonera filifolia	.	.	.	.	.	.	.	.	III
Stipa caucasica	.	.	.	.	.	.	.	.	III
Helianthemum dagestanicum	.	.	I	.	.	.	.	.	III
Viola somchetica	.	I	.	.	.	.	.	.	III
D. S. All. *Bupleuro polyphylli–Pinion sylvestris*									
Bupleurum polyphyllum	IV	V	IV	III	I	I	I	I	I
Alchemilla sericata	IV	V	IV	V	.	.	.	.	IV
Leontodon hispidus	IV	IV	II	.	.	.	.	.	.
Thalictrum foetidum	III	III	II	V	.	.	.	.	V
Ranunculus oreophilus	IV	II	III	.	.	.	.	I	.
Trifolium ambiguum	I	V	V	III	.	.	.	.	I
Filipendula vulgaris	II	III	III	.	.	.	.	.	II
Viola mirabilis	IV	I	III	.	.	.	.	.	I
Galium aparine	II	III	.	.	.	.	.	.	.
Anthriscus sylvestris	.	IV	III	.	.	.	.	.	.
Peucedanum ruthenicum	.	III	III	.	.	.	.	.	IV
D. S. All. *Asyneumo campanuloidis–Pinion sylvestris*									
Asyneuma campanuloides	.	I	.	.	IV	V	IV	III	.
Sorbus aucuparia	.	I	.	.	V	V	IV	IV	.
Hieracium prenanthoides subsp. *hypoglaucum*	.	.	.	.	II	V	III	V	.
Hieracium lachenalii subsp. *lachenalii*	.	.	.	.	IV	V	III	II	.
Vicia balansae	I	.	I	.	.	V	IV	V	.
Selinum physospermifolium	.	.	.	.	IV	II	III	III	.
Lilium monadelphum	.	.	.	.	II	II	III	III	.
Acer heldreichii subsp. *trautvetteri*	.	.	.	.	III	II	III	III	.
Aquilegia olympica	.	.	.	.	.	III	II	IV	.
Cirsium obvallatum	.	.	.	.	I	III	III	III	.
Campanula latifolia	.	.	.	.	.	II	III	I	.
D. S. Ord. *Alchemillo sericatae–Pinetalia sylvestris*									
Astrantia maxima	IV	IV	IV	V	III	V	V	V	.
Polygonatum verticillatum	IV	II	III	.	IV	IV	V	V	.
Chaerophyllum aureum	I	II	IV	.	III	III	V	V	.
Galium valantioides	IV	V	IV	I	IV	.	II	V	II
Ranunculus caucasicus	II	I	IV	II	III	IV	II	III	.
Valeriana tiliifolia	II	III	IV	III	IV	V	V	IV	.
Phedimus spurius	III	I	III	.	IV	III	II	III	.
Betonica macrantha	.	I	II	.	III	III	III	II	.
Cephalaria gigantea	.	II	II	.	III	III	IV	V	.
Campanula collina	.	III	I	.	I	V	II	II	
Cruciata laevipes	.	.	II	III	III	II	I	I	.
D. S. Cl. *Brachypodio pinnati–Betuletea pendulae*									
Pinus sylvestris var. *hamata*	V	V	V	V	V	V	IV	V	V
Betula pubescens var. *litwinowii*	IV	V	II	.	II	III	IV	V	.
Calamagrostis arundinacea	.	III	III	V	V	V	V	V	.
Fragaria vesca	IV	III	IV	III	V	I	IV	IV	II
Brachypodium pinnatum	II	.	III	.	V	.	I	III	.
Geranium sylvaticum	II	III	II	.	IV	V	III	II	.
Rubus saxatilis	I	III	IV	III	II	.	III	V	.
Primula veris subsp. *macrocalyx*	II	IV	III	IV	I	I	.	II	.
Vicia cracca	II	II	II	III	IV	II	II	III	.
Thalictrum minus	I	II	II	.	II	I	II	I	.

Table 2 (continued)

Syntaxon No.	1	2	3	4	5	6	7	8	9
Heracleum asperum	.	I	.	.	III	III	V	IV	.
Solidago virgaurea	I	.	.	.	V	I	IV	V	.
Anemonastrum fasciculatum	.	.	.	I	V	V	II	V	.
Pulmonaria mollis	.	.	.	.	V	V	I	.	.

Syntaxon No.	1	2	3	4	5	6	7	8	9
Senecio propinquus	.	.	.	.	IV	V	III	II	.
Salix caprea	II	II	.	.	.	.	III	III	.
Angelica sylvestris	.	.	.	.	.	.	II	I	.
Crepis sibirica	.	.	.	.	.	II	.	III	.
Betula pendula	.	.	II	III	.	.	.	.	.

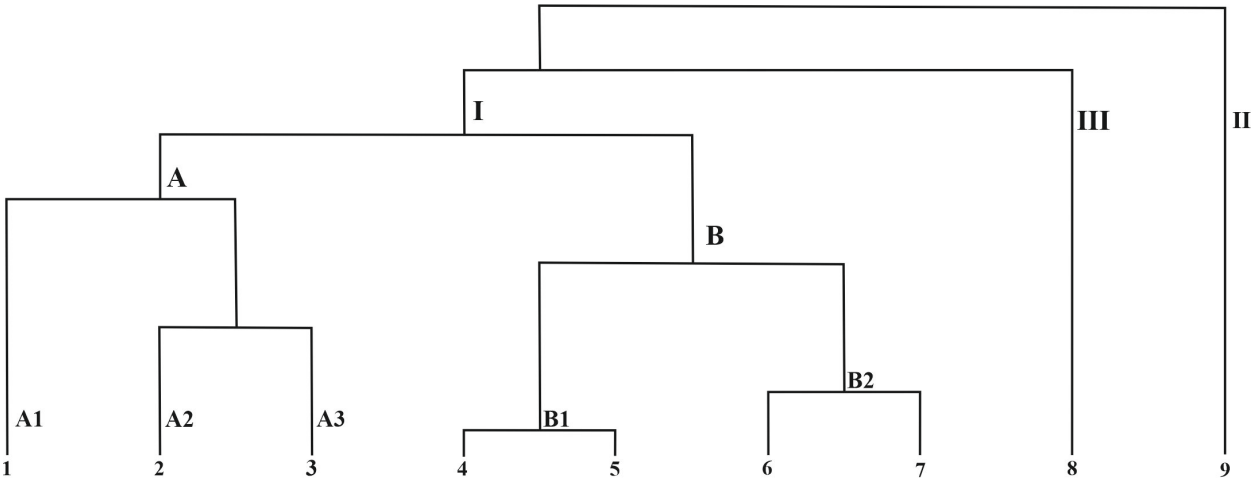

Fig. 3. Dendrogram of 7 associations and higher units of pine and pine-birch (*Pinus sylvestris* var. *hamata, Betula pubescens* var. *litwinowii*) forests from the North-Western and Eastern Caucasus.
I – Mesopilous pine and pine birch (*Pinus sylvestris* var. *hamata, Betula pubescens* var. *litwinowii*) hemiboreal forests of the order *Alchemillo sericatae–Pinetalia sylvestris* (class *Brachypodio pinnati–Betuletea pendulae*); A – the alliance *Bupleuro polyphylli–Pinion sylvestris* (A1 – association *Carici albae–Pinetum sylvestris*; A2 – association *Ranunculo caucasicae–Pinetum sylvestris*; A3 – association *Viburno lanatae–Pinetum sylvestris*); B – the alliance *Asyneumo campanuloidis–Pinion sylvestris* (B1 – association *Bistorto carneae–Pinetum sylvestris*; B2 – association *Aconito nasuti–Pinetum sylvestris*).
II – Transitional association *Calamagrostio caucasicae–Pinetum sylvestris* placed between the classes *Brachypodio pinnati–Betuletea pendulae* (cluster I) and *Erico–Pinetea* (cluster III).
III – Hemi-xerophilous pine (*Pinus sylvestris* var. *hamata*) sub-Mediterranian forests of the class *Erico-Pinetea* (the alliance *Onobrychido cornutae–Pinion sylvestris*, association *Onobrychido cornutae–Pinetum sylvestris*).

The cluster B includes two associations described in this paper – *Bistorto carneae–Pinetum sylvestris* (cluster B1) and *Aconito nasuti–Pinetum sylvestris* (cluster B2) united in the new alliance *Asyneumo campanuloidis–Pinion sylvestris* **all. nov.** representing the mesophilous pine and pine-birch grass forests of the humid cyclonic climatic sector in the North-Western Caucasus. The diagnostic species group of the alliance includes dominantly subalpine plants: *Campanula latifolia, Cirsium obvallatum, Hieracium prenanthoides* subsp. *hypoglaucum, H. lachenalii* subsp. *lachenalii, Selinum physospermifolium, Asyneuma campanuloides, Lilium monadelphum, Vicia balansae, Sorbus aucuparia, Acer heldreichii* subsp. *trautvetteri, Aquilegia olympica*. The nomenclature type (holotypus) of the alliance *Asyneumo campanuloidis–Pinion sylvestris* is the association *Aconito nasuti–Pinetum sylvestris* **ass. nov.** (described in this paper).

Clusters A and B are merged in one cluster I at the highest hierarchical level on the dendrogram (Fig. 3). It corresponds to the order *Alchemillo sericatae–Pinetalia sylvestris* Ermakov, Abdurakhmanova et Plugatar 2020 *nom. corr.* representing mesophilous birch and birch-pine grass forests of the North-Western and Eastern Caucasus.

Cluster II separated at the highest level of the dendrogram includes floristically very peculiar hemi-xerophilous pine forests from Central Dagestan (Eastern Caucasus) – the alliance *Onobrychido cornutae–Pinion sylvestris* Ermakov et al. 2020 *nom. corr.* (with single association *Onobrychido cornutae–Pinetum sylvestris* Ermakov et al. 2020 *nom. corr.*).

One association *Calamagrostio caucasicae–Pinetum sylvestris* Ermakov et al. 2019 (cluster III) located between clusters I and II keeps the transitional features between mesophilous and hemi-xerophilous forests. It was included in the alliance *Bupleuro polyphylli–Pinion sylvestris* because of predominance of diagnostic features of the latter. A synoptic table of all Caucasian pine and pine-birch grass forests syntaxa is represented in Table 2.

The results of the classification of mesophilous pine and pine-birch (*Pinus sylvestris* var. *hamata*, *Betula pubescens* var. *litwinowii*) grass forests of the North-Western Caucasus allow us to propose a new concept of their position in the system of higher syntaxonomic units. All described associations belong to a special type of zonal small-leaved and light-coniferous hemiboreal forests of Northern Eurasia (Hamet-Achti, 1981). It is confirmed by their common ecological properties, floristic compositions and physiognomy. The mesic habitats and light canopies of these communities resulting in the well-developed grass layer from a number of light-demanding and moderately cold-tolerant subalpine-forest and meadow species (Ermakov, 2003). At the same time, the alliance *Asyneumo campanuloidis–Pinion sylvestris* contains a distinct diagnostic species group of European-Siberian hemiboreal forests of the class *Brachypodio pinnati–Betuletea pendulae*: *Pinus sylvestris* var. *hamata, Betula pendula, B. pubescens* subsp. *litwinowii, Angelica sylvestris, Brachypodium pinnatum, Calamagrostis arundinacea, Crepis sibirica, Fragaria vesca, Geranium sylvaticum, Primula veris* subsp. *macrocalyx, Rubus saxatilis, Salix caprea, Solidago virgaurea, Pulmonaria mollis, Vicia cracca, Thalictrum minus*. These species are strongly related to pine and pine-birch (*Pinus sylvestris* var. *hamata, Betula pubescens* var. *litwinowii*) grass forests and only some of them are rarely found in other types of forest vegetation in the Caucasus. This species group includes also Caucasian taxa with systematically and ecologically similar vicarious species occurring in Southern Siberia: *Heraculum asperum* (*H. dissectum*), *Anemonastrum fasciculatum* (*A. crinitum*) and *Senecio propinquus* (*Senecio nemorensis*). Based on the results of the cluster analysis (Fig. 3) and characteristics listed above, we include the order *Alchemillo sericatae–Pinetalia sylvestris* (and two alliances *Asyneumo campanuloidis–Pinion sylvestris* and *Bupleuro polyphylli–Pinion sylvestris*) in the class *Brachypodio pinnati–Betuletea pendulae.* The order represents the hemiboreal forests found at the upper limit of the forest belt in the North-Western and Eastern Caucasus. The corrected group of diagnostic species includes subalpine-forest and subalpine mesophilous plants, most of which are Caucasian endemics: *Astrantia maxima, A. pontica, A. trifida, Chaerophyllum aureum, Polygonatum verticillatum, Galium valantioides, Ranunculus caucasicus, Valeriana tiliifolia, Phedimus spurius, Betonica macrantha, Cephalaria gigantea, Linum hypericifolium, Cruciata laevipes*.

The East Caucasian hemi-xerophilous pine forests of the alliance *Onobrychido cornutae–Pinion sylvestris* (with the association *Onobrychido cornutae–Pinetum sylvestris*) were left in the sub-Mediterranean class *Erico–Pinetea* (Ermakov et al., 2020) since drought-resistant species being diagnostic for this class (Mucina et al., 2016): *Leontodon hispidus, Rosa spinosissima, Helianthemum nummularium, Teucrium chamaedrys, T. polium, Salvia verticillata, Berberis vulgaris, Cotoneaster integerrimus* predominate in floristic composition (Table 2). However, the position of this alliance in the class system remains unclear and additional data are needed.

The main range of the *Brachypodio pinnati–Betuletea pendulae* covers the southern Urals and Southern Siberia (Ermakov, 2003). However, recently several associations of hemiboreal forests of this class have been described in the mountain systems of Europe (Mucina et al., 2016; Willner et al., 2016) and Asia Minor (Ketenoğlu et al., 2010; Bergmeier et al., 2019). They are found at the upper parts of the mountain ranges and are considered Pleistocene relic communities. Similarly, the North Caucasian hemiboreal forests occurring in the upper part of the forest belt and in the subalpine belt at altitudes of 1600–2300 m in a cool humid climate are isolated from the main range of zonal hemiboreal forests in Northern Eurasia and their origin may also be associated with the climate of the cold and dry periods of the Pleistocene.

Prodromus of pine forests of the Northern Caucasus

Cl. *Brachypodio pinnati–Betuletea pendulae* Ermakov, Korolyuk et Lashchinsky 1991

Ord. *Alchemillo sericatae–Pinetalia sylvestris* Ermakov, Abdurakhmanova et Plugatar 2020 *nom. corr.* (*Alchemillo sericaceae–Pinetalia sylvestris* Ermakov, Abdurakhmanova et Plugatar 2020 [Art. 41, ICPN]).

All. *Bupleuro polyphylli–Pinion sylvestris* Ermakov, Abdurakhmanova et Plugatar 2020

Association *Carici albae–Pinetum sylvestris* Ermakov, Abdurakhmanova et Potapenko 2019

Association *Ranunculo caucasicae–Pinetum sylvestris* Ermakov, Abdurakhmanova et Plugatar 2020

Association *Viburno lanatae–Pinetum sylvestris* Ermakov, Abdurakhmanova et Potapenko 2019

Association *Calamagrostio caucasicae–Pinetum sylvestris* Ermakov, Abdurakhmanova et Potapenko 2019

All. *Asyneumo campanuloidis–Pinion sylvestris* **all. nov.**

Ass. *Bistorto carneae–Pinetum sylvestris* **ass. nov.**

Var. *Rhododendron luteum*

Var. *Avenella flexuosa*

Ass. *Aconito nasuti–Pinetum sylvestris* **ass. nov.**

Var. *Centaurea phrygia* subsp. *abbreviata*

Var. *Geranium robertianum*

Class *Erico–Pinetea* Horvat 1959

Order ?

Alliance *Onobrychido cornutae–Pinion sylvestris* Ermakov, Abdurakhmanova, Plugatar 2020 *nom. corr.* (*Onobrichido cornutae–Pinion sylvestris* Ermakov, Abdurakhmanova, Plugatar 2020 [Art. 41, ICPN]).

Association *Onobrychido cornutae–Pinetum sylvestris* Ermakov, Abdurakhmanova, Plugatar 2020 *nom. corr.* (*Onobrichido cornutae–Pinetum sylvestris* Ermakov, Abdurakhmanova, Plugatar 2020 [Art. 41, ICPN]).

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